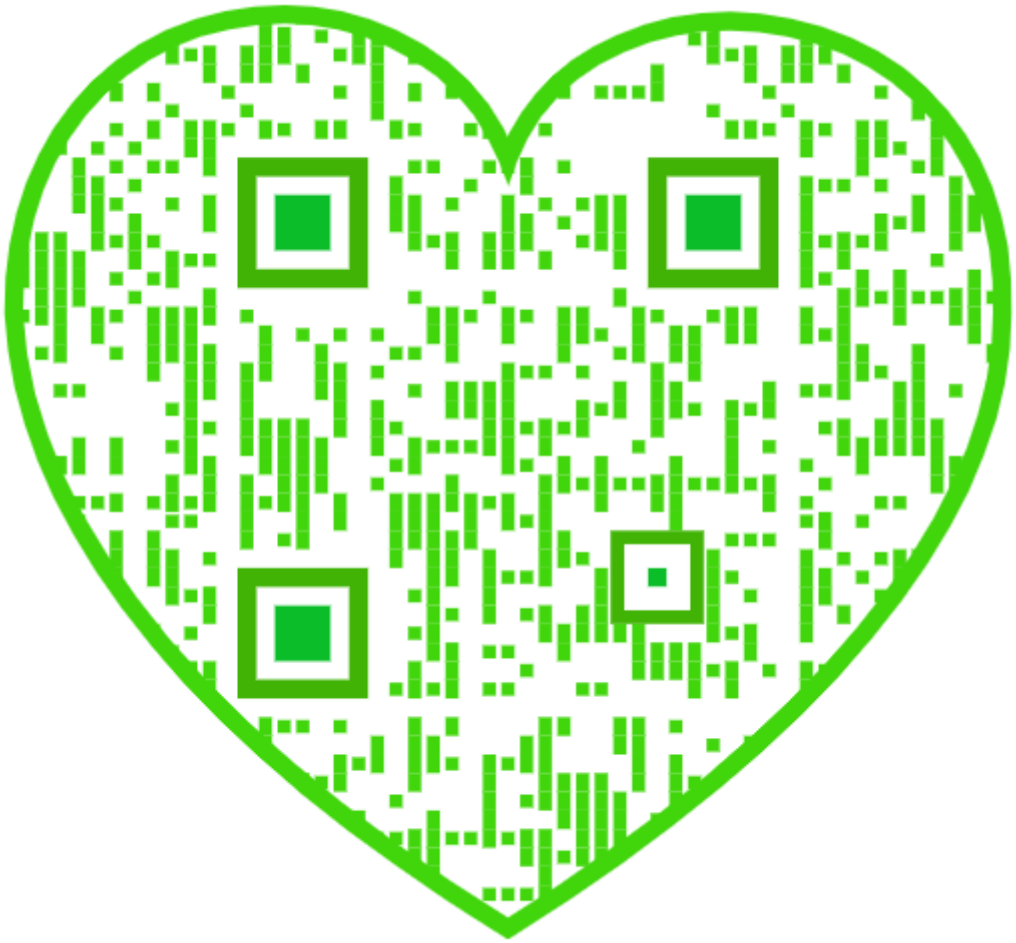

The Rural Science Series
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THE SWEET POTATO

The Rural Science Series

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THE SWEET POTATO. *Hand and Cockerham.*

PLATE 1.— A commercial sweet potato bed in Texas.

THE SWEET POTATO

A Handbook for the Practical Grower

BY

T. E. HAND

AND

K. L. COCKERHAM

New York

THE MACMILLAN COMPANY

1921

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THE SWEET POTATO

CHAPTER I

ORIGIN AND DESCRIPTION OF THE SWEET POTATO

For many centuries the inhabitants of the warmer countries of the world have recognized the usefulness of the sweet potato as a source of food. Thus Bretschneider writes[1] that the plant "was described in Chinese books a long time before the discovery of America," in the third or fourth century of our era. It was early an important cultivated plant, the roots of which supplied the place of corn in Southern China. The root was said to be reddish and as large as a goose egg. Bretschneider identifies the plant with the sweet potato.

Although the exact origin of the sweet potato is doubtful, its widespread cultivation, which in range compares favorably with that of such plants as tobacco and maize, argues for it antiquity of many centuries. The aborigines are said to have recognized such marked similarity between the sweet potato and the Irish potato that they called them by the same name, though they are not only very different species, but the

[1] Bretschneider, "Study and Value of Chinese Botanical Works," p. 13.

sweet potato is a true enlarged root while the Irish potato is a tuber of underground branches or rhizomes.[1]

Although cultivated perhaps more widely in the New World than in the Old, the sweet potato now plays a part in the vegetable calendar of gardeners in every country within or near the tropics and of recent years has become of considerable commercial importance in several regions of both North and South America.

The definite origin of the sweet potato has been much investigated and discussed for many years and there is much diversity of opinion on the subject. Although there are arguments for both its American and Oriental origin as well as the possibility of its being indigenous to both the eastern and western hemispheres, much must be learned before the question can be definitely and conclusively decided. The available evidence in favor of American origin at the present time seems to be preponderant, and this theory is the one most popular among American agriculturists.

The tuber is now widely distributed in all tropical regions and is being considerably used in the eastern countries, and by some writers who contend that it belongs to both hemispheres is "thought to have been much used by the ancient Chinese," although the food article referred to may have been the Chinese yam.

De Candolle says that Clusius (about 1600) was one of the first writers to mention the sweet potato and he quotes the latter as saying he had eaten the product in the south of Spain, where it was supposed to come from the New World.[2] Historians tell us that Columbus

[1] De Candolle gives Turpin in "Mem. du Museum," Vol. XIX, Plates 1, 2, 5, credit for having clearly shown these facts.
[2] De Candolle, "Origin of Cultivated Plants," 54.

carried sweet potatoes to Queen Isabella among his other collections from the New World. The sweet potato is not mentioned among the agricultural products of the anciently famous valleys of the Tigris and the Euphrates rivers. It is hardly possible to suppose, had it been indigenous to the Old World, that the plant would not have been grown in these regions when its characteristically hardy reproduction and ease of transportation are considered. Furthermore, philologists have found no definite Sanskrit name for the plant and although cultivated in India at the present time few kinds are known there and those that are cultivated seem to differ somewhat from the plant as known by us. The plant was not cultivated by the Arabs, Romans or Turks even a century ago.

DESCRIPTION

The sweet potato plant is a perennial, although commonly grown as an annual. It is a trailing vine of the morning-glory family which strikes root freely at the joints, bearing leaves that vary greatly in shape according to the variety. This characteristic variation in leaf shape furnishes an important means for the classification of varieties. Although in general contour resembling those of the common morning-glory, the leaves are of three types, entire and not lobed, shouldered and lobed, and deeply cut and lobed. The length of the vine varies greatly, some varieties producing very long luxuriant stems while others have a decided bushy or "vineless" habit of growth. Varietal influences also cause considerable variation in color tint of vines, leaf-stems and in structure of the

leaves themselves. Variation is also common in the prominence and abundance of leaf-veins.

Flowers and seed.— Although rarely producing flowers and less frequently maturing perfect seed in the sweet potato producing areas of the United States, occasionally a small bell- or morning-glory-shaped bloom, with a purple throat and white margin, may be noticed in commercial fields. Matured seed may be produced if the growing period is prolonged by the use of artificial means. These seeds, however, are unreliable for use in perpetuating varieties as the resulting plants cannot be depended on as coming true to the mother plant. In fact, they may differ widely among themselves. This characteristic enables the production of new varieties by selecting strong and prepotent offspring.

Tubers.— The sweet potato as known to commerce is an enlarged tuberous root. In nature this root serves as an organ for the storage of food, to be used in nourishing the young shoots from which the plant is ordinarily propagated, but man has converted this stored material to his own use. This edible tuber is much prized throughout the warmer parts of Asia and the Americas as well as to considerable extent in other semi-tropical and tropical countries as a staple article of food. The tubers are variable in shape, size and color as well as in food value and chemical constituents. Some are long and cylindrical while others are short, thick and blunt at the ends. (Plate IV.) The skin may be pink, yellowish or dull straw color, purple, red or whitish in color. The flesh is variable also in color, quality, moisture and texture. These tubers (unlike the common or Irish potato) do not bear definite eyes, but are formed in underground clusters immediately beneath

the crown of the plant. Though these tubers are botanically enlarged roots, they are seldom spoken of as such because of the confusion that may arise from the fact that the word "root" may denote either the slender fibrous feed-roots, the culls or "seed potatoes," or the enlarged edible root. The word "potatoes" is the universal term in the southeastern states while outside this territory "sweet potato" is used in contradistinction to the "Irish," "round" or "white" potato.

BOTANICAL CLASSIFICATION

The sweet potato belongs to the Convolvulaceæ or Morning-Glory family. The Convolvulaceæ is a very large and widely distributed family, making the problem of proper classification rather difficult. The sweet potato is an Ipomœa, a genus that, according to House in Bailey's Standard Cyclopedia of Horticulture, comprises "over 400 species of which more than 200 occur in Tropical America, chiefly in Mexico." Two species are native in the northeastern states, and others are run wild. The sweet potato has been accorded different designations in the divisions of this rather complex family, by various botanists. Linnæus gave the plant the name *Convolvulus Batatas,* and Choisy the name *Batatas edulis,* while Poiret put it into the genus Ipomœa, as *I Batatas,* the name it now holds.

De Candolle (Origin of Cultivated Plants) says that the word Batatas is American, coming from a mistaken transfer of "potato," and he mentions Humboldt as using the Mexican name of Camote, Clusius the words Batatas, Camotes, Amotes, Ajes, all supposed to be of American origin or at least foreign to the Old World and none referring to any of the Ipomœas. This writer

also concludes that there is no Sanskrit name for the plant and the Bengalee name of ruktalu (which he says, though being derived from Sanskrit has been mistaken for a pure derivative of that ancient language), indicates in modern languages yam and potato. Attempts have been made to connect the word Batatas with oriental languages but with indifferent success. Although the sweet potato appears to have been known in China as early as the second or third century, this fact does not prove an eastern origin. It appears to have been widely distributed by primitive Pacific peoples.

Probably it is derived, by a long process of domestication, from the tropical American *Ipomœa fastigiata*. This latter plant is described by Cook and Collins (Economic Plants of Porto Rico) as "*Bejuco de puerco*; a twining vine found in waste places; the tuberous roots are called wild potatoes in Jamaica."

The word yam is commonly applied to forms of the sweet potato, although it properly belongs only to species of Dioscorea, a very different plant. Various varieties of sweet potato yams are grown in India, Japan, Sumatra, Java, Philippines, and numerous Pacific Islands. Some of them have pyriform spindles while others assume the form of spherical rhizomes. Several species are also found in countries of South America. The word yam is supposed to have originated in Africa and in several African dialects is said to mean, "to eat." Whether the fondness of the southern negro for "Yam Taters" offers any clue to the intricacies of this early history, is not known. But the word is used with such indefinite and variable meaning by people of the United States in referring to the sweet potato, that it had best

be dropped. It is not only botanically incorrect but causes considerable confusion in markets which hinders or prevents stabilization of varietal trade demands.

CHAPTER II

IMPORTANCE AND DISTRIBUTION

THE growing of the sweet potato has become one of the most important food-producing industries. The extension of this crop has been continually on the increase for the past several years and it now ranks second only to the Irish potato as a vegetable in the United States. The value of the crop in 1917 reached the hitherto unparalleled sum of $96,121,000 and that of 1918 was estimated at $116,867,000.

Although always grown to a limited extent by practically every farmer in the cotton-belt, the sweet potato until recently has been accorded a secondary place in the average southern rotation. The increasing demand for the crop is, however, revolutionizing former cultural and storage methods and with its wide adaptability to various climatic and soil conditions, its ease of production, and with an increasing appreciation of its value as food resulting in its introduction into new sections, within the last few years there has been a rapid increase in popular favor of the crop. Alabama, producing only 6,290,000 bushels in 1916, almost doubled this yield in 1918 when it produced 14,688,000 bushels. (Tables I to V.) With the exception of certain western sections, a similar though perhaps less increased interest in production has been experienced over almost the entire sweet potato area. (Tables I to V.)

TABLE I.— SWEET POTATOES: ESTIMATES OF ACREAGE, YIELD PER ACRE, TOTAL PRODUCTION, PRICE TO THE BUSHEL, TOTAL FARM VALUE AND VALUE TO THE ACRE BY STATES IN 1918.

STATE	Acreage (000 omitted)	Yield per Acre	Production (000 omitted)	Price per Bu. Dec. 1	Total Value (000 omitted)	Value per Acre
New Jersey....	23	125	2,875	190	5,462	237.50
Pennsylvania ..	1	120	120	185	222	222.00
Delaware	5	120	600	125	750	150.00
Maryland	11	130	1,430	150	2,145	195.00
Virginia	28	120	3,360	145	4,872	174.00
West Virginia..	2	106	212	204	432	[illegible] 3.24
North Carolina.	81	110	8,910	132	11,761	145.20
South Carolina.	80	95	7,600	142	10,792	134.90
Georgia	130	92	11,960	125	14,950	115.00
Florida	36	110	3,960	125	4,950	137.50
Ohio	1	96	96	175	168	168.00
Indiana	3	108	324	195	632	210.60
Illinois	8	82	656	175	1,148	143.50
Iowa	3	93	279	210	586	195.30
Missouri	8	91	728	186	1,354	169.26
Kansas	4	80	320	222	710	177.60
Kentucky	13	95	1,235	175	2,161	166.25
Tennessee	30	98	2,940	136	3,998	133.28
Alabama	153	96	14,688	115	16,891	110.40
Mississippi	89	95	8,455	104	8,793	98.80
Louisiana	65	75	4,875	128	6,240	96.00
Texas	87	58	5,046	175	8,830	101.50
Oklahoma	15	65	975	220	2,145	143.00
Arkansas	38	90	3,420	138	4,720	124.20
New Mexico....	2	125	250	250	625	312.50
California	6	170	1,020	150	1,530	255.00
United States..	922	93.6	86,334	135.4	116,867	126.75

The farm value of sweet potatoes, which has more than doubled in the past ten years, has increased more rapidly than acreage or production. This tuber is now one of the principal vegetable foods of the southern states, and its use can be enormously increased in all

sections of the United States, especially in the northern and western areas.

DISTRIBUTION

Although the sweet potato is grown as a garden crop as far north as southern New York, northern Illinois, central Iowa and Nebraska, its commercial production is confined very largely to the South Atlantic and Gulf Coast states. A fair commercial crop is produced westward along the border line between the United States and Mexico extending into central California. (Fig. 1.)

The commercial crop is raised mainly in eighteen states: the Southeastern group, comprising Virginia, North and South Carolina, Georgia, Florida, Alabama, Louisiana and Mississippi. Sweet potatoes are grown

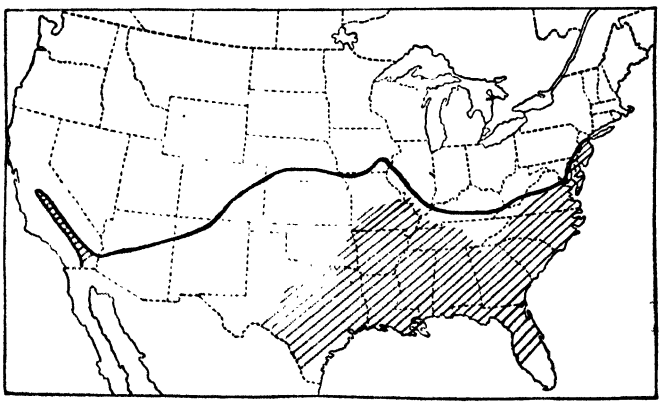

FIGURE 1.— Map showing range of production of sweet potatoes. The shaded portion represents the area adapted to commercial growing. The dark line represents the northern limits of sweet potato culture for home use.

quite extensively in Texas, Oklahoma, Tennessee, Arkansas and California, while the northern crop which figures very largely in car-lot shipments, is produced chiefly in New Jersey, Delaware, Maryland, Illinois and Iowa. Production has increased rapidly in some states, having nearly doubled between 1915 and 1918 in Alabama which gives it the leading place among the sweet potato growing states, while Georgia with an increase nearly as rapid takes second place in production. Northern and western producing sections as a whole show many decreases during recent years. However, a few small localities in these areas have developed a considerable industry by the use of large curing-houses and it is very probable that these sections will rapidly increase their acreage and yields within the next few years. Tables II, III and IV give in complete form the geographic distribution and the economic value of the sweet potato in the various sections of the United States since 1899.

TABLE II.—PRODUCTION AND VALUE OF SWEET POTATOES AND YAMS IN THE UNITED STATES, BY DIVISIONS AND STATES IN 1899 AND 1909, AS REPORTED BY THE TWELFTH AND THIRTEENTH UNITED STATES CENSUSES.

DIVISION OR STATE.	Production.		Value.	
	1909.	1899.	1909.	1899.
Geographic Divisions:	Bushels.	Bushels.	Dollars.	Dollars.
New England.....	4,818	567	4,543	346
Middle Atlantic....	3,326,190	2,662,046	1,638,902	1,349,588
East North Central	1,361,256	1,004,277	751,929	619,833
West North Central	1,696,111	1,491,275	1,095,724	805,669
South Atlantic....	29,628,153	21,881,977	16,146,222	9,183,650
East South Central	13,573,580	8,772,133	9,116,510	4,536,187
West South Central	9,025,928	6,439,547	6,265,750	3,220,595

Division or State.	Production.		Value.	
	1909.	1899.	1909.	1899.
Geographic Divisions:	Bushels.	Bushels.	Dollars.	Dollars.
Mountain	38,877	19,064	52,596	14,207
Pacific	574,157	246,526	357,000	139,765
PRINCIPAL STATES.				
Middle Atlantic:				
New Jersey	3,186,499	2,418,641	1,527,074	1,213,010
Pennsylvania	128,770	234,724	104,434	130,990
East North Central				
Ohio	133,798	249,767	104,181	158,103
Indiana	178,300	239,487	139,886	155,585
Illinois	1,050,932	511,695	506,760	303,638
West North Central:				
Iowa	232,413	224,622	125,763	128,981
Missouri	876,234	743,377	567,413	424,470
Kansas	558,021	474,810	373,432	224,049
South Atlantic:				
Delaware	733,746	222,165	276,679	96,566
Maryland	1,065,956	677,848	483,751	317,462
Virginia	5,270,202	4,470,602	2,681,472	1,720,188
West Virginia	215,582	202,424	170,086	125,523
North Carolina	8,493,283	5,781,587	4,333,297	2,119,956
South Carolina	4,319,926	3,369,957	2,606,606	1,538,205
Georgia	7,426,131	5,087,674	4,349,806	2,354,390
Florida	2,083,665	2,049,784	1,231,238	898,282
East South Central:				
Kentucky	1,326,245	925,786	839,454	507,038
Tennessee	2,504,490	1,571,575	1,625,056	883,620
Alabama	5,314,857	3,457,386	3,578,710	1,687,039
Mississippi	4,427,988	2,817,386	3,073,290	1,458,490
West South Central:				
Arkansas	1,685,308	998,767	1,359,669	534,616
Louisiana	4,251,086	1,865,482	2,357,729	859,733
Oklahoma	359,451	*a* 276,163	350,553	*a* 137,231
Texas	2,730,083	3,299,135	2,197,799	1,689,015
Pacific:				
California	572,814	239,029	355,624	135,612
All others	106,290	107,539	109,414	68,048
United States	59,232,070	42,517,412	35,429,176	19,869,840

a Includes Indian Territory.

TABLE III.—SWEET POTATOES: ESTIMATES OF ACREAGE, PRODUCTION AND VALUE 1912–1913.

STATES	Acreage (000 omitted)		Yield per Acre		Total Production (000 omitted)		Price per bu. Dec. 1 to Producers		Value based on price Dec. 1 to Producers (000 omitted)	
	1912	1913	1912	1913	1912	1913	1912	1913	1912	1913
	Acres	Acres	Bu.	Bu.	Bu.	Bu.	Cts	Cts.	Dolls.	Doll.
New Jersey	23	23	120	138	2,760	3,174	84	78	2,318	2,476
Pennsylvania	1	1	120	110	120	110	75	90	90	99
Delaware	5	5	120	135	600	675	68	60	408	405
Maryland	8	8	125	141	1,000	1,128	63	60	630	677
Virginia	33	33	90	108	2,970	3,564	75	70	2,228	2,495
West Virginia	2	2	115	91	230	182	90	109	207	198
North Carolina	75	80	90	100	6,750	8,000	62	61	4,185	4,880
South Carolina	48	50	105	92	5,040	4,600	68	75	3,427	3,450
Georgia	81	83	90	87	7,290	7,221	66	68	4,811	4,910
Florida	21	21	112	110	2,352	2,310	73	75	1,717	1,732
Ohio	1	1	118	90	118	90	87	106	103	95
Indiana	1	1	116	78	116	78	89	103	103	80
Illinois	8	8	98	70	784	560	95	106	745	594
Iowa	2	2	90	80	180	160	108	150	194	240
Missouri	6	6	88	56	528	336	95	105	502	353
Kansas	5	5	99	50	495	250	103	110	510	275
Kentucky	9	9	90	75	810	675	85	94	688	634
Tennessee	20	20	90	80	1,800	1,600	72	80	1,296	1,280
Alabama	62	70	100	95	6,200	6,650	71	67	4,402	4,456
Mississippi	52	55	97	98	5,044	5,390	62	62	3,127	3,342
Louisiana	56	60	84	85	4,704	5,100	65	70	3,053	3,570
Texas	36	50	75	80	2,700	4,000	104	95	2,808	3,800
Oklahoma	4	6	92	64	368	384	109	104	401	399
Arkansas	18	20	88	90	1,584	1,800	90	80	1,426	1,440
California	6	6	156	170	936	1,020	94	100	880	1,020
United States	583	625	95.2	92.5	55,057	59,057	72.6	72.6	40,264	42,884

TABLE IV.—SWEET POTATOES: ESTIMATES OF ACREAGE, PRODUCTION AND VALUE 1914–1915.

STATES	Acreage (000 omitted)		Yield per Acre		Total Production (000 omitted)		Price per bu. Dec. 1 to Producers		Value based on price Dec. 1 to Producers (000 omitted)	
	1914	1915	1914	1915	1914	1915	1914	1915	1914	1915
	Acres	Acres	Bu.	Bu.	Bu.	Bu.	Cts.	Cts.	Dolls.	Dolls.
New Jersey	23	23	100	155	2,200	3,565	95	70	2,090	2,496
Pennsylvania	1	1	105	105	105	105	86	75	90	79
Delaware	5	5	120	135	600	675	70	62	420	418
Maryland	8	8	125	130	1,000	1,040	70	70	700	728
Virginia	31	34	92	110	2,852	3,740	76	65	2,168	2,431
West Virginia	2	2	92	110	184	220	98	92	180	202
North Carolina	76	85	90	105	6,840	8,925	65	56	4,446	4,998
South Carolina	48	65	85	105	4,080	6,825	70	65	2,856	4,436
Georgia	79	95	85	85	6,715	8,075	69	61	4,633	4,926
Florida	19	23	120	112	2,280	2,576	80	68	1,824	1,752
Ohio	1	1	110	95	110	95	96	98	106	93
Indiana	1	2	100	104	100	208	90	90	90	187
Illinois	8	8	84	110	672	880	95	82	638	722
Iowa	2	3	100	95	200	285	127	108	254	308
Missouri	6	7	84	100	504	700	96	82	484	574
Kansas	5	4	110	110	550	440	106	100	583	440
Kentucky	10	10	105	105	1,050	1,050	77	70	808	735
Tennessee	25	27	100	105	2,500	2,835	69	59	1,725	1,673
Alabama	63	80	93	90	5,859	7,200	65	57	3,808	4,104
Mississippi	50	75	90	110	4,500	8,250	63	55	2,835	4,538
Louisiana	59	65	87	92	5,133	5,980	64	50	3,285	2,990
Texas	52	60	101	98	5,252	5,880	87	70	4,569	4,116
Oklahoma	6	12	102	115	612	1,380	89	73	545	1,007
Arkansas	18	30	95	130	1,710	3,900	77	61	1,317	2,379
California	6	6	161	135	966	810	87	80	840	648
United States	603	731	93.8	103.5	56,574	75,639	73.0	62.1	41,294	46,980

TABLE V.—SWEET POTATOES: ESTIMATES OF ACREAGE, PRODUCTION AND VALUE 1916–1917.

STATES	Acreage (000 omitted)		Yield per Acre		Total Production (000 omitted)		Price per bu. Dec. 1 to Producers		Value based on price Dec. 1 to Producers (000 omitted)	
	1916	1917	1916	1917	1916	1917	1916	1917	1916	1917
	Acres	Acres	Bu.	Bu.	Bu.	Bu.	Cts.	Cts.	Dolls.	Dolls.
New Jersey	23	24	100	120	2,300	2,880	120	160	2,760	4,608
Pennsylvania	1	1	100	110	100	110	135	140	135	154
Delaware	5	5	125	112	625	560	81	120	506	672
Maryland	9	10	126	118	1,134	1,180	88	100	998	1,180
Virginia	39	34	130	104	5,070	3,536	90	110	4,563	3,890
West Virginia	2	2	140	140	280	280	126	140	353	392
North Carolina	87	90	107	95	9,309	8,550	75	105	6,982	8,978
South Carolina	66	80	86	95	5,676	7,600	85	104	4,825	7,904
Georgia	94	125	80	93	7,520	11,625	81	105	6,091	12,206
Florida	25	35	100	95	2,500	3,325	86	115	2,150	3,824
Ohio	1	1	99	95	99	95	150	175	148	166
Indiana	3	3	100	106	300	318	150	165	450	525
Illinois	8	8	90	97	720	776	125	150	900	1,164
Iowa	3	3	91	90	273	270	192	210	524	567
Missouri	7	8	70	112	490	896	150	141	735	1,263
Kansas	4	4	92	92	368	368	150	160	552	589
Kentucky	10	12	90	95	900	1,140	100	125	900	1,425
Tennessee	27	30	100	95	2,700	2,850	87	105	2,349	2,992
Alabama	85	150	74	90	6,290	13,500	74	92	4,655	12,420
Mississippi	77	85	82	65	6,314	5,525	67	97	4,230	5,359
Louisiana	64	62	90	79	5,760	4,898	66	104	3,802	5,034
Texas	80	84	89	78	7,120	6,552	90	140	6,408	9,173
Oklahoma	13	15	74	90	962	1,350	135	160	1,299	2,160
Arkansas	35	40	91	110	3,185	4,400	90	96	2,866	4,224
New Mexico	.....	2	.....	118	.....	236	.....	205	.....	484
California	6	6	160	167	960	1,002	100	150	960	1,503
United States	774	919	91.7	91.2	70,955	83,822	84.8	110.8	60,141	92,916

CLIMATIC REQUIREMENTS AND SOIL TYPES

A liberal rainfall, with warm nights and abundant sunshine, lasting throughout the growing season, with less moisture during the two months preceding maturity, constitute ideal weather conditions for sweet potatoes. A growing period of at least 130 days is essential for the production of maximum yields.

While requiring a heavy rainfall during the late spring and summer to insure vigorously growing plants and the formation of an abundant and well-shaped tuber crop, considerably less rain is needed as the time of harvest approaches. In fact, much rain at this time may result in a considerable loss to the grower by injuring the flavor of the potato and greatly impairing its keeping and shipping quality. An unusually long continued spell of wet weather in the fall has often resulted in great loss to growers along the Atlantic and Gulf coasts, sometimes causing the entire crop to rot in the field and more often causing a souring of the potato which makes it easily susceptible to disease attack on the slightest bruising, and rendering it practically impossible of successful storage. This condition occurred throughout all the counties bordering the Gulf of Mexico in the fall of 1918 and in the same year the crop was more or less injured all along the Atlantic coast. (The handling of the crop under these conditions is fully treated under Chapter X.) It is also believed by some growers that heavy late rains increase the tendency to cracking or splitting in the tubers, although the scientific reason for this common occurrence has not yet been satisfactorily determined. Such late rains following a dry season, though not excessive, tend to create a re-

newal or second growth of the tubers which causes excess sappiness and makes handling in transit more difficult. On the other hand, severe drouths late in the season make harvesting tedious.

Where irrigation must be practiced, as will be necessary in some parts of Texas, New Mexico and Arizona, most of the water should be applied between the time the plants are set and the ground becomes covered with vines. The water is withheld altogether for several weeks preceding harvest, to permit the proper ripening of the tubers.

A climate with an abundance of sunshine and warm nights is necessary for thrift. A temperature ranging from 70 to 100 degrees F. during the summer growing period is a good average for maximum yield, although in a small way "sweets" may be produced under a wide range of temperatures as well as soil types. North of the cotton-belt, the sweet potato is commonly regarded as a garden crop.

The sweet potato crop is exceedingly sensitive to frost and growth is noticeably checked by cool weather. Growers in the southern Gulf states have found it profitable to set their plants in the field a little later in the spring rather than have them stunted by the cool nights. The sweet potato is strictly a summer crop and grows best in the hottest part of the year.

It requires about four and one-half months for the sweet potato to reach normal maturity. A potato that is immature is harder to keep in storage and shrinks more than one fully mature. The amount of starch, sugar and other constituents as well as their form and availability differ materially at various periods of growth. The relative length of the growing period is

the limiting factor of production as the line indicative of profitable growth is moved northward.

The sweet potato finds its most desirable soil environment when planted on light friable loam or sandy soil with a yellow clay subsoil. A well-drained soil that is warm and loose with a good proportion of sand in the top soil and a subsoil fairly retentive of moisture provides ideal conditions. A moderately fertile sandy loam lacking an excess of undecayed organic matter is preferable, although a fairly good yield can often be obtained on soils too poor for the production of most farm crops. Large yields of the most desirable market type of potatoes are sometimes produced on some of the driest and most sandy soils when the growing conditions are favorable, but care in the selection of suitable areas usually pays in greatly increased returns. The depleted cotton and tobacco lands of the South can be made to give excellent returns in sweet potatoes when intelligent care is exercised to provide a supply of humus in the soil by a leguminous crop in the rotation. The loams and mixed sandy soils of northern Louisiana, the friable chocolate loams of northeast Texas, the cut-over long-leaf yellow pine lands of Mississippi, Alabama, Georgia, and Florida, northern and eastern South Carolina, the lower sand hills and coastal regions of North Carolina, eastern Virginia, lower New Jersey and Delaware, the sandy localities of the Kaw and Arkansas valleys in Arkansas and eastern and southern Tennessee, all afford soil types well suited to the commercial production of this important food crop. Other sections of these same states, as the Piedmont regions of northern Georgia and North Carolina, supply soil conditions possible of profitable development but re-

quiring different treatment and handling. The custom of planting on high ridges is for the purpose of facilitating drainage. A porous clay subsoil not only supplies drainage without the leaching of plant-food but it is an important factor in the production of well-shaped tubers. A very deep sandy soil without a substantial foundation permits the loss of valuable fertilizing elements by leaching and often produces long ill-shaped potatoes that do not bring the highest prices on discriminating markets. The surface soil should be six or eight inches deep and the subsoil should provide drainage without leaching. A stiff soil favors excessive vine growth and the production of rough irregular potatoes. Such soils also are usually cold and in the end will prove unprofitable for commercial plantings. The sweet potato is possible of profitable growth on a wider range of soil than perhaps any other of the common field crops.

CHAPTER III

UTILIZATION OF THE SWEET POTATO

THE most important use of the sweet potato is as a food for man, either in its original form or as manufactured into a flour or starch. It may also have an important place in the rations for live-stock.

T. E. Keitt [1] of South Carolina gives the chemical analysis of the sweet potato vine (average of four varieties) and tubers (average fourteen varieties) respectively to be:

TABLE VI.— ANALYSIS OF SWEET POTATO TUBERS AND VINES.

	Dry Matter	Protein	Nitrogen Free Extract	Fat	Fiber	Ash	Water
Sweet Potato Tubers....	39.1	1.6	27.9	0.5	0.9	1.0	68.1
Sweet Potato Vines — Fresh	17.0	2.1	9.5	0.8	3.1	1.5	83.0

Attention is called to the fact that the nitrogen-content of the sweet potato occurs in the readily available form of albuminoids which render this food element capable of full utilization in digestion processes. This is an important item to be considered in calculating the comparative food value of this crop with that of some other crops which, although containing a higher percent-

[1] Bull. 146, S. C. Exp. Sta., 1908.

age of nitrogenous substances, are not worth so much in actual feeding value because of the unavailable form in which they occur.

AS FOOD FOR MAN

As a food for human consumption, the sweet potato has always been held in very high esteem by the peoples of the southern United States, South America, parts of Asia and many of the tropical islands. In the Philippines and Hawaiian Islands, it furnishes one of the main sources of food supply, notwithstanding the fact that there is no trade in the crop aside from purely local markets.

The sweet potato is highly nutritious and contrary to the common belief is easily digested. If ingenuity is employed in its utilization, many palatable ways of serving it are available, such as baked, boiled, served with meats, in soups, candied, in salads, desserts, and even for the production of sirup and as a flour substitute. Its use is also developing in making desserts, cereals, cakes and various drinks.

Composition and food value.

Although the sweet potato differs botanically from the Irish potato, in general chemical composition the root resembles very closely the tubers of the white potato. There are, however, some important differences as shown in Table VII.

It will be noted that the sweet potato as purchased has a fuel value in calories equal to approximately one-half more than does the white potato. The water contained is less than that of the white potato and although

TABLE VII.— COMPOSITION OF THE SWEET POTATO AND IRISH POTATO COMPARED.

KIND OF POTATO	Refuse Per cent.	Water Per cent.	Protein Per cent.	Fat Per cent.	Carbohydrates		Ash	Food Values Per Pound
					Sugar, Starch, etc.	Crude Fiber		Calories
Sweet potato (edible portion).	.....	69.0	1.8	0.7	26.1	1.3	1.1	560
Sweet potato (as purchased) ..	20.0	55.2	1.4	0.6	21.9	.....	.9	450
Sweet potato (cooked)	.....	51.9	3.0	2.1	42.1	.....	.9	905
Sweet potato (canned)	.....	55.2	1.9	.4	40.6	.8	1.1	800
White potato — for comparison (edible portion).	.....	78.3	2.2	.1	18.0	.4	1.0	375
White potato — for comparison (as purchased)	20.0	62.6	1.8	.1	14.7	.....	.8	305

the percentage of crude fiber is slightly higher, it is about that commonly found in most vegetables (see Table VIII). Although it would seem that the white potato is slightly higher in protein, actually the sweet potato contains more available protein. This is explained by the fact that a large part of the protein in the white potato occurs in the form of amides which are not available as food. The sweet potato is considerably richer in fat and contains a perceptibly greater percentage of available carbohydrates than does the white potato. The ash-content is approximately the same and about the same waste occurs in peeling. As indicated

by the table, sweet potatoes contain considerable quantities of sugar. This sugar-content is influenced to a marked degree by the climatic conditions under which the roots are grown, tropical varieties often containing as much sugar as starch, while those grown in the northern areas of the United States often average less than 7 per cent sugar, or less than one-fourth of their total carbohydrates.

Few crops will yield an equal amount of valuable food stuff with as little expense of production. The sweet potato is especially rich in nitrogen free extract which consists primarily of sugar and starch. Both of these food elements are producers of heat and energy. Fats and carbohydrates, containing carbon as the essential element, are only valuable for fuel. On the other hand, protein, containing nitrogen, is the essential element in tissue building and is necessary in any balanced ration whether for man or other animal. Lean meat, the white of egg, milk, beans and peas furnish the most familiar examples of foods high in protein. Sweet potatoes in any ration must be supplemented by such foods. About 10 per cent of the total number of heat units consumed in any human ration should be protein. This does not mean 10 per cent of the total weight or bulk but 10 per cent of the total nutriment. In other words, out of every 100 calories of food consumed only ten calories of protein are needed. A diet containing 10 per cent protein, 30 per cent fats and 60 per cent carbohydrates is a well balanced one. In the preparation of a palatable wholesome and well balanced meal, the housewife will find no more economical and satisfactory source of carbohydrates than in the sweet po-

tato; pound for pound the sweet potato contains about one-half more available food than does the more commonly used Irish potato.

Aside from the purely chemical food value of the sweet potato, it supplies valuable mineral salts which are not obtained in cereal carbohydrates. These mineral salts, which are composed largely of potassium compounds, are very valuable in offsetting the acid effect brought about by meats and other common protein foods in the body. To maintain the system in a state of vigor and efficiency, the general diet should be neutral or slightly alkaline rather than overly acid. Nothing is so valuable as an alkaline medicine as fresh vegetables and in supplying these mineral salts the sweet potato, because of its many ways of preparation and palatability, will be found to rank well in the list of cheaply available vegetables. The sweet potato is easily prepared and has the goods points of a cereal plus the advantages of a vegetable. Although containing less fat and protein than most cereals, it furnishes the body a large proportion of mineral substances. A cupful of boiled potatoes would furnish the body with about as much energy as a cupful of boiled rice. Although the available protein in the sweet potato may be a little more easily digested than that of the Irish potato, yet the difference is so small as to be negligible. All experimental data available indicates a degree of digestibility equal to that of white potatoes.[1] C. F. Langworthy says, "It is a matter of common experience that sweet potatoes are wholesome, and they are ordinarily digested without distress. Many persons find the starchy

[1] Bull. 468, U. S. Dept. Agr., page 21.

varieties so dry that they do not relish them without large quantities of butter. This makes a rather rich mixture and is perhaps accountable for the digestive disturbances occasionally experienced. Considering both composition and digestibility, it may be said that the nutritive value of sweet potatoes is much the same as that of white potatoes and that they are well fitted to occupy the same place in the diet and furnish a palatable substitute for white potatoes. The characteristic and pleasing flavor has the advantage of giving variety to the diet. In the North they frequently cost somewhat more than white potatoes, but are still among the cheaper vegetables. In the South they are usually cheaper than white potatoes and merit their extensive use."

AS FOOD FOR DOMESTIC ANIMALS

In consideration of the great need with which this country is confronted, and especially the South, for a cheaper and more easily produced carbohydrate than corn, sweet potatoes might well be considered as a source of this food element for all domestic animals. Owing to the ease with which it is produced, the exceptional food value and the readiness with which it is consumed by practically all domesticated animals, it is natural to expect that the sweet potato will play a more important part in food rations as its general production is increased. Heretofore, when the consumption of this crop has been limited to a few weeks in the fall when the hogs were turned on the fields to dig up the roots left by oversight, little attention was paid to feeding it and little was thought of its feeding value. With the advent of improved storage houses from which

the tubers can be taken at any season of the year as conveniently as corn from the crib, farmers are rapidly giving more attention to the possibilities of the crop as a source of nutritious, succulent and palatable foodstuff for their live-stock. At present sweet potatoes cured in the storage-house bring midwinter prices, which makes them prohibitive for feeding purposes when convenient transportation facilities are available. However, many farmers live too far from the railroad to make hauling to market of such a bulky crop profitable and they will always find it a good policy to preserve the crop for feeding purposes. The very interesting results recently obtained by the Florida Experiment Station with the feeding of sweet potato silage to dairy cattle opens up a new field in the feeding of the crop. Feeding to live-stock will always be a profitable way of marketing the culls, the bruised and ill-shaped crop. All kinds of stock relish them and because of the high content of dry matter, they possess a decided advantage over the other root-crops. They can be depended on to contain an average of 10 per cent more dry matter than the Irish potato, and more than 20 per cent more than common beets, mangels, turnips, rutabagas, carrots or parsnips. (Table VIII.) The yield in many sections is larger than that of the Irish potato and the "sweets" are not so subject to disease and insect enemies in the field, nor are they so expensive to fertilize, propagate and cultivate. The following table[1] gives the average feeding stuff analysis of several similar crops and also that of corn:

[1] Bull. 146, S. C. Exp. Sta.

TABLE VIII.— SHOWING ANALYSIS OF VARIOUS FEEDING STUFFS.[1]

CROP	Per cent. Water	Per cent. Ash	Per cent. Protein	Per cent. C. Fiber	Per cent. N. Free Extract	Per cent. Ether Extract
Irish potato....	78.9	1 0	2.1	0.6	17.3	0.1
Beets, common..	88.5	1.0	1.5	0.9	8.0	0.1
Beets, mangels..	90.9	1.1	1.4	0.9	5.5	0.2
Beets, sugar....	86.5	0.9	1.8	0.9	9.8	0.1
Turnips	90.5	0.8	1.1	1.2	6.2	0.2
Rutabagas	88.6	1.2	1.2	1.3	7 5	0.2
Carrots	88.6	1.0	1.1	1.3	7.6	0.4
Parsnips	88.3	0.7	1.6	1.0	10.2	0..
Artichoke	79.5	1.0	2.6	0.8	15.9	0.2
Sweet potato...	68.1	1.0	1.6	0.9	27.9	0.5
Corn	10.6	1.5	10.3	2.2	70.4	5.0

Keitt says concerning the analysis of the above crops: "On land in this State (meaning South Carolina) which under the ordinary system of cropping, yield 20 bushels of corn, we should be able to produce about 200 bushels of sweet potatoes. The potatoes would furnish more than three times as much nitrogen free extract and as much or more of each of the other proximate constituents contained in the corn. From the preceding table, we will note that the Irish potato contains 2.1 per cent. of protein, which is more than the amount contained in the sweet potato; but about one-half of the calculated protein of the Irish potato is really nitrogen present in the form of amides, which do not have the feeding value that the albuminoids have. In order to determine whether or not any of the nitrogen present in the sweet potato was present in the form of amides,

[1] All of the analyses were taken from Henry's "Feeds and Feeding" except that of the sweet potatoes, which represent the average analysis of fourteen varieties by T. E. Keitt, chemist of the S. C. Exp. Sta.

we made determinations on all of the varieties and found that there were no amides present."

Importance in the proper balancing of the farm animal's ration cannot be over-emphasized. The proper proportion of heat and energy producing foods with muscle builders must be fed for economy as well as for the well-being of the animal. It is too often neglected to give a sufficient amount of fat and carbohydrates with the protein feed. Although protein when supplied in over-abundance will partly do the work of carbohydrates, it is an expensive means of supplying it. One part of protein in the food should be supplemented with six parts of fats and carbohydrates for a milk cow. When much more protein than this is used, it cannot be assimilated by the animal and so is lost in the manure. As Keitt points out, a mixture of 8 pounds of sweet potatoes to 1 pound of cotton-seed meal would give a nutritive ratio of approximately six to one. Such a ration if periodically supplanted by other rations to avoid getting the animal "off-feed" will give good results. The value of this crop in the production of milk has been aptly illustrated in recent tests with the ensilage.

Sweet potato silage.

The first record of making the crop into silage was in 1912 when the Florida Experiment Station conducted feeding experiments with sweet potatoes. The roots were run through the ensilage cutter and handled the same as any other crop. The comparative analysis of corn and sweet potato silage was as follows:

TABLE IX.—SHOWING COMPARATIVE ANALYSIS OF CORN AND SWEET POTATO SILAGE.

CROP	Water	Crude Protein	Nitrogen F. Extract	Fiber	Fat	Ash
Sweet potato silage ...	54.87	1.82	39.41	1.48	.66	1.85
Well matured corn silage	75.7	2.1	15.4	6.3	.80	1.7

Attention is called to the fact that there is very little difference in apparent feeding value. There is, however, about two and one-half times as much nitrogen free extract and considerably more dry matter in the potato silage; and experience showed the potato silage to be from 50 to 100 per cent more valuable.

In a test lasting forty-three days, divided into twenty-day periods with three days between periods for the purpose of changing feeds, the following results were secured [1]: "Ten cows were used in the test and were divided into two lots of five cows each. During the first period each animal in lot one was given the following daily ration; wheat bran 8.4 pounds, cotton-seed meal 2.8, and sweet potato silage 10.6 pounds. Each animal in lot two was given the following daily ration: Wheat bran 8.4 pounds, cotton-seed meal 2.8, and sorghum silage 15.2 pounds.

"During the second period feeds were reversed, that is, the cows in lot one were given the feed that lot two had received and those in lot two were given the feed that lot one had received.

"During the experiment the cows fed sweet potato silage, wheat bran and cotton-seed meal produced 2641 pounds or 307.1 gallons of milk. During the same

[1] Jno. M. Scott, Press Bull. 274, Fla. Exp. Sta.

length of time the cows fed sorghum silage, wheat bran and cotton-seed meal produced 2415.8 pounds or 280.9 gallons of milk, a difference of 225.2 pounds or 26.2 gallons of milk in favor of sweet potato silage.

"One noticeable fact in this experiment is that the cows ate one-third less sweet potato silage than sorghum silage. This is quite a saving in the amount of feed consumed by a herd during the year."

Scott of the Florida Station is very enthusiastic over the silo as a means of preserving the crop for the dairy cow. He gives the advantages of preserving as; "No loss in storage; they require less space for storage; and there is no waste in feeding." It is possible that this form of silage will come into more general use throughout the South when more is known of its feeding values.

Roots.

The roots without any special preparation are grown extensively throughout the South for feeding purposes, especially for hogs. The Tuskegee Experiment Station of Alabama found that hogs put on almost as much fat with sweet potatoes alone as with wheat shorts alone.[1] This station also found that a grain ration of corn could very economically be cut in half by substituting from 2¾ to 3½ pounds of potatoes for 1½ pounds of corn in feeding mules doing heavy work. Four mules were used in the test. They kept in as good condition and were able to do as much work as the four check animals which were fed corn exclusively.

Planted in June and early July, they will be ready

[1] Geo. W. Carver, Bull. 30, Tuskegee Normal and Ind. Inst., p. 1.

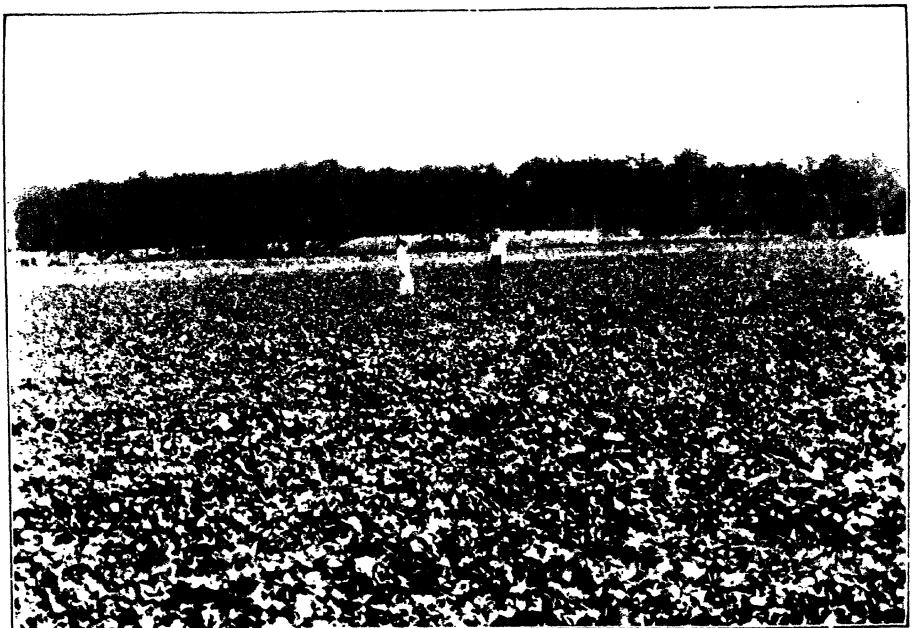

PLATE II.—Fifty acre field of sweet potatoes, Thomasville, Georgia.

for hog-grazing in October. An acre of sweet potatoes should feed eight or ten hogs weighing 200 pounds for a period of two months, provided supplemental feeds are used to balance the ration. Hogs will often root up more than they will eat immediately but little or no loss results. It has been found that some of the heaviest yielding varieties, such as the Yellow Strasburg, Red Bermuda, Southern Queen and White Belmont, may be left out in the field with but slight injury, for feeding purposes. Care should be taken in feeding frost-bitten potatoes to horses, mules and cattle as they are very sweet at this time and stock eat them ravenously. They should never be fed to any stock other than hogs after they have become sour. Hogs eat them, however, with no apparent bad results. For fall and early winter grazing, the sweet potato is preëminently the best crop for hogs that can be grown in the South. The cut-over pine lands of that region will doubtless owe their development as a hog-raising country largely to the fact that these soils are ideally suited to the growth of sweet potatoes, which furnish excellent grazing during the period when other grazing crops are getting a start before severely cold weather; and to the perfectly balanced ration secured when supplemented with other easily grown grazing crops, such as peanuts, soybeans, and cowpea pastures. Such a combination will certainly result in the production of economical pork.

Beattie [1] has suggested the production of excellent stock feed by growing some of the heavy yielding varieties of sweets, drying and pulverizing them and adding enough concentrates to form a balanced ration. As

[1] Farmers' Bull. 324, U. S. Dept. Agr.

yet no means have been perfected by which they may be converted into a condensed stock food on the farm economically. It will be noted (Table VIII) that both the protein and fat-content are relatively low. If peanuts, which are rich in these two elements, are ground in the shell and mixed 1 bushel to 3 of sweet potatoes, a well-balanced ration will be secured. Three bushels of sweet potatoes are usually considered equal in feeding value to 1 bushel of corn; but experience has shown that supplemental concentrated feeds and especially ones rich in protein should be used if a satisfactory feed is obtained.

Vines.

The vines of the sweet potato when properly cured make a fair quality hay for feeding cattle and sheep. Though the vines turn black when dried, they are greedily eaten by all kinds of stock. The principal objection to saving vines for hay is the difficulty of harvesting. They not only lie flat on the ground but root freely, making them very tedious and expensive to gather. Cattle, hogs and sheep readily eat the green vines in the field but the food value is relatively small in this state. In chemical analysis, however, the cured vines compare favorably with some of our prominent hays. Keitt [1] gives the following comparison of the average analysis of red clover, crimson clover, cowpea and soybean hays with that of hay made from sweet potato vines. The analysis of the potato vines represents an average of four varieties; Brazilian, Polo, Southern Queen and Nancy Hall.

[1] T. E. Keitt, Bull. 146, S. C. Exp. Sta., p. 16.

TABLE X.—COMPARATIVE ANALYSIS OF SWEET POTATO VINES.

WATER-FREE	Protein	Fat	Fiber	Ash	Nitrogen Free Extract
Red clover hay.....	14.52	3.90	29.28	7.32	44.98
Crimson clover hay...	16.81	3.08	30.09	9.51	40.51
Cowpea hay.....	18.59	2.46	22.51	8.40	48.14
Soyabean hay	17.36	5.86	25.14	8.12	43.52
Average	16.82	3.83	26.76	8.34	44.25
Sweet potato vines....	12.48	4.86	18.22	8.73	55.71

The plants with which the potato vines are compared in the above table are among our most nutritious hays and attention is called to the fact that they are all legumes. Although the average protein-content is about 4 per cent greater than that contained in the potato vines, the percentage of both fat and nitrogen free extract is decidedly in favor of the latter. It will also be noticed that the fiber-content is relatively high in all of these hays compared, which is of course the least valuable of any food constituent.

Although analysis shows a very favorable comparison, the actual value as a hay in practical feeding is yet to be demonstrated by determining the real digestibility and power of utilization by animals of the food constituents.

Unless cheap labor is available and the cost of harvesting thereby reduced, it will often be more profitable to leave the vines on the ground to decay and supply organic matter than to undertake their manufacture into hay.

MANUFACTURED PRODUCTS OF THE SWEET POTATO

The manufacture of sweet potatoes into various food forms which can be more systematically handled in

commerce than can the product in the natural state includes canning, desiccating or dehydrating, from which process of reducing the water-content such by-products result as potato flour and chips. All of these processes are means of changing the same food into a different form that marketing may be facilitated. In addition to these strictly food manufacturing industries, at least two other side-line or strictly speaking by-product commercial endeavors are possible of considerable development; one of these is the manufacture of starch and the other is the possibility of alcohol manufacture from the fermentable carbohydrates contained in the roots.

Dehydrated and desiccated sweet potatoes. (Figs. 2–5.)

In recent years the dehydration of various vegetables has been undertaken extensively in certain sections by numerous manufacturing concerns, and to a more limited extent on a small scale in the home. This process consists in removing the water from the products by means of heating after the vegetables have been first sliced or cut into small pieces. Perhaps no other one vegetable offers better possibilities of development as a food

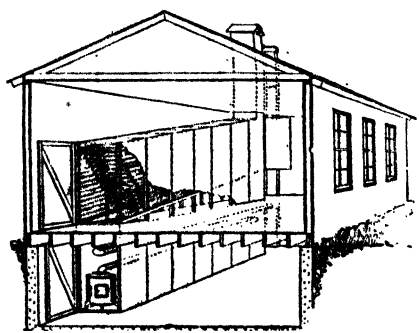

FIGURE 2.— Showing possible construction of a commercial sweet potato desiccating plant.

through this means than does the sweet potato. The dehydrated potatoes, ready for use, appear in two forms, i. e., sliced and the "riced" or granulated forms. The sliced pieces are 1 to 3 inches long, ¼ to ½ inch wide and about ⅛ inch in thickness. The "riced" product appears as small grains about the size of a grain of rice. The sliced article is very hard and usually requires soaking overnight before using. Some of the granulated kinds require soaking while others may be boiled immediately. Both of these forms are used largely in making pies and for seasoning soups. Dehydrated potatoes may be purchased commercially in packages ranging from one pound and upward. Although the dehydrating industry is still in its infancy, it bids fair to furnish an excellent medium through which sweet potatoes may be exported and thus become of use in regions where it is now impossible to obtain them. The dehydrated product may be kept indefinitely and handled as any other staple article of food.

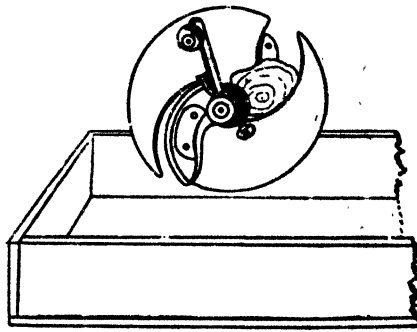

FIGURE 3.—A rotary slicer that may be used in slicing sweet potatoes.

Dried sweet potatoes have for many years been prepared at home by hanging strings of them from the rafters in the kitchen together with other drying fruits and vegetables. This practice has, however, been

largely supplemented by preservation in the modern farm storage-houses. Many special devices for evaporating fruits and vegetables are on the market which can be used economically for sweet potatoes. Desiccated sweet potatoes prepared in much the same way as desiccated white potatoes are now sold to some extent in everyday commerce.[1]

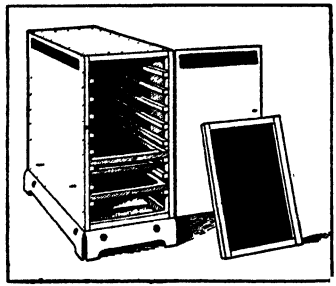

FIGURE 4.—A portable outdoor evaporator to be heated by an ordinary stove.

For meeting the needs of the ordinary family, there are a considerable number of small driers, both patented and unpatented, intended to be operated over the cook-stove and in connection with the usual routine of the kitchen.[2] Very simple drying devices may be made at home by providing single racks or trays made of wire cloth secured to

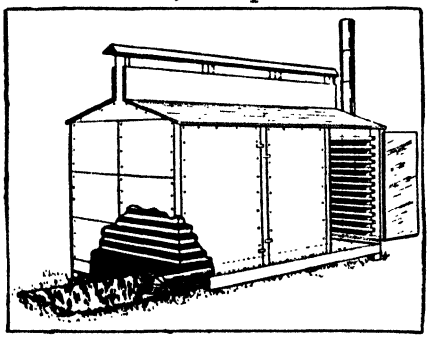

FIGURE 5.—A home-made drier constructed of sheet iron in operation over a small stove.

[1] Bull. 468, U. S. Dept. Agr., page 20; Bull. 71, S. C. Exp. Sta., 1903, page 6; Farmers' Bull. 169, U. S. Dept. Agr., 1903, page 25.

[2] For full description of various types of driers, see Farmers' Bull. 984, U. S. Dept. Agr.

wooden frames of the desired size, and suspended above the cookstove. Fig. 4 shows a very efficient but inexpensive cookstove drier which is well adapted to the desiccation of sweets. A somewhat similar drier is shown in operation in Fig. 5. The housewife will frequently find it convenient to dry sweets in the stove oven without any special apparatus.

The desiccation of sweet potatoes is especially valuable in disposing of the small, extra long or ill-shaped roots. In preparing for the drying process, they should be washed and peeled with as little waste as possible, after which they are cut into slices or split lengthwise into quarters or eighths according to size. Peeling must ordinarily be done by hand or with a rotary slicer (Fig. 3). The rotary peelers sometimes used for Irish potatoes are not satisfactory for the sweets. The slices should be as near the same thickness as possible to insure uniform drying. As the potatoes are sliced, they should be blanched by dipping into boiling water from six to ten minutes. The sliced pieces are placed in a wire basket, or wire-bottom box, to a depth of not over 6 inches and plunged into the water, which should be boiling violently enough to stir and separate the slices. If cut into slices ¼ inch thick, six to eight minutes is sufficient for blanching, but when cut into larger pieces ten minutes is necessary to secure the desired results. Blanching is done to prevent darkening and it is desirable to prolong the blanching process until partial cooking results. As soon as blanched, they should be drained quickly and placed in the drier. A beginning temperature of 145° to 150° F. should be used and as the product loses moisture, this should gradually be raised to around 160° F. Drying is com-

plete when the slices become brittle and break readily under pressure. The dried material is used for cooking in the same way as other dried root-crops.

Sweet potato flour.

With the beginning of the War, every effort was made to determine the most economical and convenient substitutes for wheat flour in making bread. Among the many important wheat substitutes derived was sweet potato flour. There are several grades of this flour and quite as many ways to manufacture it. Flour may be made from the raw potato, from the cooked product and from the pulp resulting from the by-product manufacture of starch (page 39).

Sweet potato pie product.

Sweet potato pies are considered a delicacy in all sections of the South. As a result of the widespread use for this purpose, canning factories in some sections are manufacturing a special pie product. This pie filler is put up in two- and three-pound tins and is ready to be used without further preparation. It is commonly manufactured by peeling, mashing and then cooking the potatoes, after which a sufficient quantity of ribbon cane sirup is mixed with it to form a thick semi-fluid substance. The natural sugar of the potato and the cane sirup combined furnish a delicately sweet pie filler which is rapidly becoming popular over a wide area. The red or yellow varieties which have a relatively high sugar-content are preferred to the mealy and less sweet kinds in making this product.

Sweet potato chips.

Sweet potato chips are now manufactured to a limited extent by some dehydrating concerns They are put on the market in much the same form as the commercial Irish potato chips, which are packed in waxed paper boxes. The sweet potato chips, however, usually require other preparation before using.

Sweet potato sugar.

In addition to its high starch-content which is largely capable of being converted into sugars, the sweet potato also contains several per cent of free sugars (more than 4 per cent of sucrose has been found in the roots). The fermentation of this saccharine matter is embodied in the manufacture of alcohol. Though the commercial manufacture of sugar from this crop has not yet been undertaken, it is possible that the next few years will witness concerted effort in this direction.

Starch manufacture.

Carver[1] has described the home manufacture of starch as follows: "This is very easily made; all that is necessary is to grate the potato, the finer the better, put into a cheese cloth or thin muslin bag and dip up and down in a vessel of water, squeezing occasionally. Continue washing as long as the washings are milky. Allow it to settle five or six hours or until the water becomes clear, pour off; rewash the starch, which will be in the bottom of the vessel, stir up well, allow to settle again, pour off the water and let it dry. Keep the same as any ordinary starch." Starch made in this

[1] G. W. Carver, Bull. 37, Tuskegee Normal and Ind. Inst.

way was equal if not superior to corn-starch in cooking and it was found that an excellent quality of library paste having powerful adhesive power could be manufactured from it.

A theoretical yield of approximately ten pounds of pure starch to each bushel of sweet potatoes has been secured in the laboratory with scientific methods. The following table gives the analyses of fourteen varieties and shows an average of 18 per cent starch, although it will be noted the starch-content varies considerably with different varieties. The analyses were made by Keitt of the South Carolina Station who calls attention to the fact that "one indication which appears worthy of note is that the water content as a rule varies from

TABLE XI.—SHOWING CALCULATED RATE OF YIELD PER ACRE, WATER-CONTENT, STARCH-CONTENT, AND YIELD IN POUNDS PER ACRE.

VARIETY	Rate of yield per acre in Bu.	Per cent. Water	Per cent. Starch	Pounds of Starch per Acre
Nancy Hall	270.0	68.75	17.82	26.94.0
Polo	281.0	72.53	14.85	23.37.0
Southern Queen	416.0	68.38	19.07	44.43.0
White Spanish	141.0	67.27	20.05	15.83.0
General Grant	191.0	66.52	17.30	18.50.0
Brazilian	450.0	65.45	16.46	41.48.0
Arkansas Beauty	158.0	72.80	14.43	12.77.0
Tenn Notch Leaf	281.0	68.87	16.71	26.29.0
Yellow Nansemond	214.0	72.12	13.50	16.18.0
Purple Yam	180.0	65.57	19.40	19.56.0
Pumpkin Early Yellow Yam	270.0	62.20	20.63	30.48.0
Shanghor Yam	174.0	65.82	23.89	23.28.0
Vineless Bunch Yam	141.0	69.84	19.22	14.83.0
Fullerton Yellow Yam	326.0	67.74	18.72	34.18.0
Average	249.5	8.11	18.	24.86.5

NOTE — The bushel per acre yield being calculated from small areas can be taken only as comparative.

65.0 and 69.0 per cent and it seems that any considerable increase of this percentage is accompanied by a corresponding decrease in the starch content — the percentage of starch being about as many per cent below the average as the water content is above the average. There are three striking examples of this,— the Polo, the Arkansas Beauty and the Yellow Nansemond; all of these varieties containing over 72 per cent water and below 15 per cent starch."

White-fleshed varieties would probably be better suited to commercial starch manufacture, since yellow kinds might discolor the starch. It is possible that with care in selection, the starch-content of specific varieties could be increased. This possibility and other phases of starch manufacture from the sweet potato offer a wide field of study for the scientific investigator.

Alcohol manufacture.

When a solution of sugar is fermented by mixing with a certain kind of yeast (*Mycoderma cervisiae*) and kept at a certain required temperature until carbon dioxide ceases to be given off, there is formed the familiar substance known as alcohol. The sugars necessary for the fermentation of alcohol may be obtained from a large number of possible sources. In the commercial manufacture of this product, no cheaper means of production has been found than by making use of the fermentable saccharine matter contained in such crops as rye, barley, wheat and other grains. A number of fruit juices and vegetables may be made to yield alcohol by fermenting. In addition to about 18 per cent starch which is capable of fermentation by first con-

verting into sugars, the sweet potato also contains an average of about 4 per cent actual sugar, making an average of about 22 per cent of alcohol-producing material. Keitt found that a bushel of sweet potatoes would produce on an average a little more than a gallon of commercial alcohol. As varieties differ materially in starch and sugar-content, the amount of alcohol produced by a given quantity of sweet potatoes would naturally be influenced by varietal kind. With the increased demand for denatured alcohol in art and science, it is probable that this crop will furnish an important source of raw material for manufacture.

Sirup from sweet potatoes.

Experiments conducted in the Bureau of Chemistry, United States Department of Agriculture, have produced a palatable and wholesome sirup from sweet potatoes. The method is recommended particularly for home use when there is an over-supply of sweet potatoes that cannot be marketed to advantage. It is not advocated at present for commercial use, because it is believed that sweet-potato sirup cannot compete on a commercial basis with grain sirups. The process of manufacture is described as follows: [1]

" The sweet potatoes should be washed, any decayed portions or other blemishes removed, and then weighed. They are then placed in a kettle with plenty of water and boiled until thoroughly soft. From 1½ to 2 hours' boiling is required. The potatoes are then mashed in the kettle in the water in which boiled, with sufficient water, adding more if necessary to form a thick, smooth, mushy liquid. The temperature of the mixture is then

[1] " Weekly News Letter," U. S. Dept. Agr., Feb. 12, 1919, p. 6.

brought to 140° F., and a quantity of ground malt added equal to 3½ per cent of the weight of the original sweet potatoes. The mixture is thoroughly stirred and allowed to stand for a few minutes at a temperature of 140° F., and the temperature is then brought with constant stirring to a temperature of 150° F., the source of heat removed, and the mass allowed to stand with occasional stirring for an hour. The mixture, known technically as the 'mash,' is now pressed in cloths to separate the liquid and solid portions. The material is placed in cloth bags, which are closed, and the bags subjected to gentle pressure while kneeding. The juice flows out readily, leaving the pulp behind. The juice is now boiled down to sirup in an ordinary kettle.

"Any of the common varieties of sweet potatoes can be used. Freshly harvested stock will yield a sirup somewhat less sweet than sweet potatoes which have been harvested for some time.

"The sweet potatoes should be cooked with plenty of water. It is necessary to obtain a fluid, mushy mass which can be mixed readily with the malt.

"Great care must be taken that the temperature of the mass be uniform throughout during the action of the malt.

"Ordinary brewer's or distiller's malt of good quality gives excellent results, or the malt can be made by sprouting barley under proper conditions. In preparing malt from barley the following method will give satisfactory results: The grain should be soaked in water for 12 hours. The water is then drained off and the grain allowed to stand for 12 hours, and the operation of soaking and standing repeated during the next

24 hours. At the conclusion of the steeping, the interior of the grain should be soft and chalklike. The grain is then spread upon a tray in a layer not over 6 or 8 inches deep. The temperature at which the sprouting grain is kept is of great importance in the successful manufacture of malt. It should be kept as near 60° F. as possible. After the grain has grown for six or eight days the sprout forces its way out at the end of the grain opposite to the rootlet, and the malt may be used with excellent results at this time. Sprouting, however, may be allowed to continue slowly for another six or eight days, or even longer, until the sprout has attained a length from three to four times that of the grain. The grain must be kept moist, so that the rootlets do not wither during the sprouting period and should be turned over and thoroughly mixed at least once a day and kept covered with a wet cloth and in the dark. The product is known as 'green malt.' It should have a fresh odor and be free from any sour smell, and should be free from mold. Immediately before use the green malt should be finely ground in an ordinary meat chopper or other suitable machine. When so ground it forms a pasty mass and may be added directly to the boiled mashed sweet potatoes and the mixture thoroughly broken up by stirring until the malt is thoroughly disseminated.

"On a small scale this is most readily accomplished as described. On a large scale an ordinary cider press, using racks and cloths, can be successfully employed. The liquid obtained is slightly sweet and rather turbid. Plenty of water should be used in order to produce a mash from which the liquor will freely flow and in which a large proportion of the sugars may be easily

removed by a single pressing. The total quantity of water used should be two or three times the weight of the potatoes. The sweet-potato sirup can be boiled down to as thick a consistence as desired. The pulp which remains can be dried and used for feed, or it can be fed while fresh."

Canned sweet potatoes.

The commodity in this form is now finding a wide and ready sale over the entire country. There are many canning factories in the South and Southeast, especially along the coast lines where fish products may be obtained during the season when potatoes are scarce. These industries are opening up an extensive trade which has not been developed before. Practically every town along the Gulf Coast has one or more canning factories which handle sweet potatoes exclusively during a large part of the year. The commercially canned product appears in two- and three-pound tins. They may be cooked in any way except baked, as they are peeled and somewhat mashed in the canning process. The red or yellow varieties are preferred for canning because of the dark color assumed by the white potatoes after cooking.

J. H. Barrett and Son, manufacturers of canned goods at Westminster, South Carolina, who are among the most successful canners of sweet potatoes in the South, have given the following method for steam canning:

"I have been packing sweet potatoes for over ten years and I lose very few cans, not over one or two to the thousand. I peel the raw potatoes on an Imperial machine, cutting the large potatoes in several pieces,

making them a uniform size so that the entire cooking will be thoroughly done at the same time. I cook in a copper kettle using steam, without any water as the steam makes enough moisture. After the potatoes are thoroughly cooked I remove them from the kettle and pack them in cans, filling the can full of soft cooked potatoes, then I cap and cook the potatoes one hour at 260° dgrees of heat, then remove the potatoes from cooker immediately and let them cool. If you will carry out this method your potatoes will keep all O.K., but do not let your potatoes remain out too long from the first cooking in the kettles until you cook them the second time — not over one hour."

Other canning recipes with steam pressure canning machines and tin cans are: [1]

Recipe No. 1.—Boil or steam potatoes until three-fourths done; peel and pack dry into No. 3 cans, being sure to get full pack, then seal. Exhaust 8 to 10 minutes at boiling temperature and tip. Cook or process these cans 70 minutes at 10 pounds pressure.

Recipe No. 2.— Cook potatoes until thoroughly done; skin and mash with an ordinary masher. Pack solidly into cans and finish as in recipe No. 1. If No. 2 cans are used for the mashed potatoes, they should be cooked 55 minutes instead of 70 minutes.

Canning with glass jars and hot water is not so satisfactory as when steam canning facilities are available.

DOMESTIC COOKING OF SWEET POTATOES

It is thought by many that sweet potatoes are at their best when prepared in the simplest way, that is, cooked

[1] Miss Cornelia Simpson, canning specialist, Tex. A. & M. Coll.

or boiled. Even so, a very wide variety is possible, for it has been said that sweet potatoes may be prepared in more than a hundred ways. Specific ways of preparation will be given as briefly as possible. The recipes contained herein have been carefully selected from the great bulk of information published because of their practicability and ease of execution; these have been thoroughly tried out and recommended by the United States Department of Agriculture and food specialists of the various state departments of agriculture.

Northern and southern tastes differ as to what is a desirable quality in a sweet potato. The moist sweet varieties are preferred in the South while the North generally prefers a dry mealy root. Long cooking will, however, make any sweet potato moist.

("T" indicates tablespoons.)

BAKED SWEET POTATOES

Wash the potatoes and bake the same as white potatoes. Small ones will bake in half an hour, while very large ones will require an hour or more. If the potatoes are desired very moist and sweet, bake from 1 hour to 2 hours depending on size.

BROWNED SWEET POTATOES

Boil medium-sized sweet potatoes 45 minutes. Peel them and cut in halves lengthwise. Put them in a baking pan and baste with savory drippings, and season with salt. Cook them in a hot oven for 20 minutes.

FRIED SWEET POTATOES

Parboil the potatoes, peel, cut in slices, and fry to a nice brown in boiling lard. They can be fried without boiling, though it will require a longer time and more lard or butter.

CANDIED SWEET POTATOES

Candied sweet potatoes are very popular on southern tables, and are extremely palatable when well prepared. Cut boiled sweet potatoes into long slices, place in an earthen dish, put lumps of butter on each slice, and sprinkle with sugar. Some cooks add a little water also. Bake until the sugar and butter have candied and the potatoes are brown.

SWEET POTATO BISCUIT

½ cupful mashed sweet potatoes, 1 cupful flour, 4 teaspoons baking-powder, ½ teaspoon salt, 2 tablespoons butter or lard, milk sufficient to make a soft dough. Sift the flour, salt, and baking-powder together several times; add these to the potatoes, mixing in with a knife. Now work the fat into the mixture lightly; add the milk; work quickly and lightly until a soft dough is formed; turn out on a floured board; pat and roll out lightly until about one-half inch thick; cut into biscuits; place on buttered or greased pans, and bake 12 or 15 minutes in a quick oven.

SWEET POTATO BREAD

(Enough for two large loaves). 6 cups sifted flour (more if flour is soft), 2 cups mashed sweet potato (luke-warm), ½ cup lukewarm water (this will not be required if liquid yeast is used), 1 cake yeast, dry or compressed or ½ cup liquid yeast, 1 T sugar, 1 T salt, 2 T shortening, if desired. To the cool mashed potato add the salt, the sugar, and about 4 ounces of the flour (1 scant half pint of sifted flour), and mix thoroughly. Next add the yeast, which has been rubbed smooth in a cup with 4 tablespoons of lukewarm water. To get all the yeast, rinse the cup with the remainder of the half cup of water and add this also to the potato. Cover and place the bowl out of the way of drafts and at a temperature of 80° to 88° F. Allow this mixture to rise for two hours or until very light.

To this sponge add the melted shortening and the remainder of the flour, kneading thoroughly until a smooth and elastic dough has been formed. Do not add more water

to the dough unless it is absolutely necessary in order to incorporate all the flour. Set the dough back to rise again for 1 hour or until light. Bake allowing it to rise in the pans only until two and one-half times the original volume.

If desired the sponge for this bread may be set in the evening using only one-fourth as much yeast as directed for the quicker method. In warm weather keep this sponge cool. Rolls may be made from this mixture.

SWEET POTATO MUFFINS

1½ cups cooked sweet potato (Irish potatoes may be used instead, with or without the sugar), 1½ cups sifted white flour, 1 teaspoon salt, 2 teaspoons baking-powder, 2 T sugar, 2 eggs, 2 T shortening, liquid sufficient to make a rather stiff batter (about ½ cup). Boil the potatoes in the skins until tender, drain, peel and mash fine. Putting the potato through a ricer or colander is better than mashing. Sift together the flour, salt, sugar and baking-powder twice. Beat the eggs until light and add to the cool mashed potato. Next add the melted shortening, then the flour mixture, alternating with portions of the liquid, until a batter is formed somewhat stiffer than for ordinary flour muffins. Drop by spoonfuls into greased muffin pans until half filled and bake 20 to 25 minutes in a fairly hot oven.

SWEET POTATO SALAD

Cut hot boiled sweet potatoes into very small pieces. To 1 cup diced potatoes add ½ cup chopped peanuts and 1 T of thin mayonnaise or French dressing. Arrange on lettuce leaves and garnish with stiff mayonnaise.

SWEET POTATO PEANUT CROQUETTES

3 cups mashed potato, 1½ teaspoons salt, 2 T fat, 1 egg (beaten slightly), ¾ cup chopped nuts, and a little milk if mixture is too stiff. Shape into croquettes. Dip in crumbs, beaten egg, into crumbs again and fry in deep fat. Drain and serve hot.

BAKED SWEET POTATO CUSTARD

1 egg, 1½ cups scalded milk, ½ cup mashed sweet potato, ½ teaspoon vanilla, 2 T sugar. Beat egg, add sugar, mashed potato and scalded milk. Pour into greased individual baking dishes, place in pan of hot water and bake until set. Raisins or nuts may be added. Serve with caramel sauce.

SWEET POTATO A LA AGNES

If you use grate or open wood fires, this will prove an attractive supper dish. Bury the sweet potatoes in the ashes and cover with coals or allow to stand under grate. Roast for about two hours. The skin will be very dark when finished. Remove from ashes, wipe off potatoes, open the skin and take out potato. Serve hot with a spoonful of mayonnaise dressing on each potato.

SWEET POTATO WITH RAISINS AND MARSHMALLOWS

2 cups mashed, boiled, or baked sweet potato, 3 T butter, ½ teaspoon salt, hot milk enough to moisten. Beat, adding ½ cup chopped raisins or prunes. Pour into greased baking dish, brush top with milk, and brown in oven. Just before removing from oven stick marshmallows half way into mixture and keep in oven until marshmallows have toasted. Serve hot.

The marshmallows and raisins may be omitted and the potatoes served as mashed potatoes. The mashed potatoes may be varied by adding a sirup of 2 T molasses and 1 T butter cooked together for five minutes. This can be poured over the mashed potatoes, and bake until they are very brown.

SWEET POTATO DEVIL'S FOOD

1 cup mashed sweet potato, ¼ cup sugar, ¼ cup fat, 2 teaspoons milk, 1 egg, ¼ cup raisins, ¼ cup hickory-nuts, 1 cup flour, 4 teaspoons baking-powder, 2 teaspoons melted chocolate, 1 teaspoon cinnamon, ½ teaspoon cloves, ½ teaspoon nutmeg, ¼ teaspoon salt.

Cream fat, sugar, add beaten egg, mashed potato, melted chocolate, milk. Sift flour and measure. Add other dry in-

gredients to flour and sift into mixture. Add nuts and raisins. Bake in greased pans and combine in and frost two layers with the following frosting: ⅓ cup water, 1 cup sugar, 1 egg, ½ teaspoon vanilla. Cook water and sugar together until the sirup threads when dropped from a spoon. Remove from fire and beat into stiffly beaten egg-white. Add vanilla and beat until consistency to spread.

SWEET POTATO DROP COOKIES

2 cups mashed sweet potatoes, 1¼ cups sugar, 4 teaspoons baking-powder, 1 teaspoon cloves, ½ cup raisins, 1 egg, ½ cup fat, 2 cups flour, 1 teaspoon cinnamon, ½ teaspoon nutmeg, 1 teaspoon salt. Cream fat and sugar. Add beaten egg, mashed potatoes, dry ingredients sifted together and raisins. Drop from spoon on greased tin and bake in moderately hot oven.

BOILED SWEET POTATOES

The roots are washed and boiled as Irish potatoes, but without peeling. When sufficiently done to permit piercing with a straw, take up and peel; when large, cut lengthwise; place in covered dish and pour melted butter over them. Boiling is especially popular in the North where the varieties grown are commonly dry and mealy.

SLICED AND BAKED SWEET POTATOES

Slice roots that have been boiled until nearly done, place butter sprinkled with sugar between slices; continue layer of butter and sugar and potato slices alternately until baking dish is full. Add a small quantity of water and bake thoroughly.

RICED SWEET POTATOES

Force boiled sweet potatoes through a ricer, or a coarse strainer into a hot vegetable dish. Avoid rehandling in order to keep the potatoes light and attractive in appearance. Riced sweet potatoes are particularly appropriate with roast beef, roasted chicken or any meat served with gravy.

SWEET POTATO FLOUR

There are several grades of this product and quite as many ways to manufacture them. Each one of these flours or meals (as most millers insist on calling them) has a particular character of its own and is therefore adapted to certain uses the other products are not. The sweet potato flours are, generally speaking, of three kinds: (1) Those made from the uncooked potato; (2) those made from the cooked potato; (3) those made from a careful system of roasting, or from the starch making process. The first two will be of most interest to the housewife.

FLOUR NO. 1 FROM THE RAW POTATO

Here all that is necessary is to wash, peel, and slice the potatoes very thin, dry in sun, oven or dryer until the pieces are quite brittle, grind very fine in a coffee or spice mill, or any type of mill that will make wheat flour or corn-meal; bolt through fine cloth in the same way as for other flours. The fine flour-like particles will pass through, and the coarse granular meal left on the bolting cloths. This kind of flour is good for making mock rye bread, ginger snaps, wafers, waffles, batter cakes, custards, pies, and the like. Bread can be made with it, but it makes a dough deficient in elasticity, bread dark in color and a loaf which dries out quickly.

The coarser meals can be cooked in a great variety of ways and make very palatable dishes; they are to be soaked in warm liquid (whatever is desired to cook them in), when soft proceed as for grated potatoes.

FLOUR NO. 2 FROM COOKED POTATOES

For the making of this flour the potatoes are boiled, or steamed (preferably the latter) until done, sliced or granulated by mashing or running through a food chopper and dried until they become very brittle. They are made into flour and meal exactly the same as given for Flour No. 1. This kind of flour is especially good for bread, cakes, pies, puddings, sauce, gravies, custards, and so on. A loaf may be made in the proportion of one-third sweet potato flour to

two-thirds wheat flour. Many experiments have proven that either the mashed sweet potato or the sweet potato flour may be used in bread as high as 50 per cent but at this point it becomes decidedly potato-like in texture and flavor but not unpalatable or unwholesome.

FLOUR NO. 3 FROM PULP

This flour is make from the pulp after the starch has been removed. It is dried without cooking, ground and bolted exactly the same as recommended for the other flours. When made into puddings, pies, blanc-mange, and the like, the same as shredded cocoanut, it resembles it very much in taste and texture and is very palatable and is a most welcome addition to the dietary. It can also be used in the making of bread and is especially valuable when a loaf is desired without the least sweet taste, and with as little starch and sugar as possible.

SWEET POTATO STARCH

This is very easily made, all that is necessary is to grate the potato, the finer the better, put into a cheese cloth or thin muslin bag and dip up and down, in a vessel of water, squeezing occasionally, continue washing as long as the washings are very milky. Allow it to settle five or six hours or until the water becomes clear, pour off; rewash the starch, which will be in the bottom of the vessel, stir up well, allow to settle again, pour off the water and let dry; keep the same as any ordinary starch. Used exactly the same as cornstarch in cooking. As a thickening agent, 1 tablespoon of sweet potato starch thickens 1 cup of liquid to the consistency of a thick sauce or makes a pudding of the proper consistency for molding.

CHAPTER IV

PROPAGATION

THE sweet potato produces seed in North America only when the growing season is prolonged by artificial means. The more common varieties are propagated by means of sets taken from the tubers (called "seed") themselves and from cuttings or vines from the growing crop. The "draws," as they are commonly called in the South, are produced by bedding the tubers in a specially prepared bed where they are sprouted and the young plants removed three or four times as they appear, being set in the field as would the seedlings of cabbage, tomatoes or similar plants. This practice furnishes the most economical method of propagation. The tubers themselves are sometimes planted directly in the field where they are to grow in much the same way as with the common potato. When this method is employed, several plants often appear in one hill, which necessitates thinning. Its use is restricted to special areas or to cases influenced by peculiar conditions. Propagation by vine-cuttings has been practiced quite extensively and very satisfactorily in all of the southern states. This practice is especially popular for the late crop and there are several arguments in favor of its more extensive use in controlling disease, in the production of potatoes to be stored, and in rendering production more economical. At a sweet potato

conference held in connection with the annual meeting of the Association of Southern Agricultural Workers in Birmingham, Alabama, in 1919, the terms "slips," "sprouts," "draws" and "plants" were officially decided on as designating plants derived from bedded potatoes, while "cuttings" and "vine-cuttings" should refer to the cut ends of vines used for rooting.

In the extreme southern part of the United States, notably in southern Florida and also in some of the neighboring tropical islands, the potatoes are sometimes left in the ground from one year to another. This practice would be more widely followed but for the excess water often present in the soil in these southern areas, which causes the tubers to rot. In a dry season or on high ground even near the water where the winters are always mild, as in southern Florida, the crop may remain in the ground without injury. In such cases, the tubers are removed for use as needed and in the spring those which are left sprout and produce slips which may be transplanted or allowed to remain on the same ground.

By far the most important method of propagation and that which is primarily depended on by practically all commercial growers of this country, is the use of plants produced in the artificial or preliminary seed-bed. In fact, the recent gain in popularity of the sweet potato as a food crop has created such a demand for sweet potato plants of pure varieties by the general public, that individual growers have found the "slip" business a very profitable commercial enterprise. In many sections individuals have developed this business into an industry of no mean economical importance. Several dealers in the Central West bed annually more

than 10,000 bushels of tubers, selling the plants to smaller growers at a good profit. This specialization has not only been made remunerative by ingenious and industrious planters, but, because of the economy possible in handling large quantities, has been of real service to the smaller planters. The larger number of farmers who plant less than an acre usually find it more convenient and economical to purchase their plants than to grow them at home. Planters growing more than an acre usually prefer to prepare their own seed-bed and grow their sets at home. From 6 to 8 bushels of seed potatoes are required to produce enough plants to set an acre at one drawing. Usually three or four drawings may be made, 3 or 4 bushels of seed producing enough plants for an acre. It requires from 8,000 to 10,000 plants to set an acre (Plate III). Although as many as 4,000 plants have been produced from a single bushel of seed, the average production ranges from one-third to one-half this number with three or four drawings. The question of proper seed selection with reference to the influence on yield and quality of the field product and the control of disease is now known to be of more importance than was formerly thought.

SELECTING SEED (I. E., TUBERS FOR PROPAGATING)

Although the value of individual hill selection has been fully demonstrated with the common potato, experimental data available on the same subject with the sweet potato is not so complete. The commonly followed practice of using the culls and stringy tubers for seed has been the subject of much controversy with little conclusive data substantiating either side of the argument. However, practical growers have long

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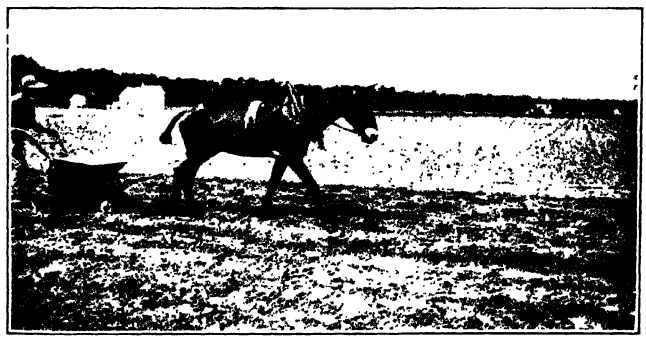
b



c

PLATE III.— Sweet potato field operations. *a*, A field of sweet potatoes after the vines have practically covered the ground. *b*, Dropping and setting draws by hand. *c*, A horse-drawn fertilizer distributor in operation.

recognized the importance of seed selection as a means of controlling disease and popular opinion seems to have indicated merit in the theories commonly advanced with reference to the influence of more careful selection over yield and characteristics of the resulting crop. Recent experiments on the eastern shore of Virginia have strengthened this belief. There are several considerations in selecting seed which plain judgment would dictate as being worthy of practical execution for the sake of a conservative system on the farm if for no other. One of the greatest hindrances to systematic marketings, especially from the more southern areas, is the mixed condition of the varieties. As the only means of mixing is by mechanical mixture of the tubers themselves, this condition is inexcusable. It can be entirely eliminated by careful selection and handling of the seed stock.

Selecting "seed" (tubers) for disease control.

Seed selection is of the very first importance in sweet potato growing from the standpoint of controlling diseases. A number of diseases seriously affect the crop in the field and unless care is taken to choose clean healthy seed, these diseases may be carried into storage and later into the seed-bed where they are transmitted to the propagating plant stock. One of the greatest troubles in the way of a successful storage is the bringing in from the field of decay organisms which would never have been present had proper precautions been taken in selecting the seed which produced the field crop. A comparatively short time ago sweet potato diseases were practically unknown, but now it is often difficult to secure disease-free seed. Many of the dis-

eases, such as soil-stain and foot-rot, can be controlled effectively by selection and the danger even from soft-rot and black-rot can be greatly lessened by careful culling and the use of proper disinfecting agencies on the seed to be bedded. (Chapter VIII.) Only sound potatoes free from soft spots should be selected for bedding. Tubers with suspicious looking spots should be avoided for seed purposes. It is best to obtain these seed from plots known to be free from field diseases. Freedom from disease should be the governing factor in selection rather than disease resistance. The tubers for bedding should be selected at time of harvesting, carefully handled to prevent bruising and consequent infection by disease, and carefully stored to prevent freezing and injury from other sources.

For yield and quality.

It is now commonly recognized that the only basis for the improvement of the sweet potato is the hill unit. Bin selection is not sufficient. Hill selection, followed for two years on the eastern shore of Virginia, practically doubled the yield.[1] The practice in Virginia is to select from hills with five or more marketable potatoes. Quicker results will be secured if the standard is placed higher and selection made from hills showing ten or more marketable potatoes. The market demands a smooth, medium-sized, spindle-shaped potato; and this standard should be kept in mind in selecting the seed stock, although use of the small tubers from high yielding hills seems to have no bad effect.

[1] Report of the conference on sweet potato problems and on diseases of cotton, corn and tomatoes, Birmingham, Ala., Feb., 1919.

Small or medium-sized roots are usually selected for seed purposes since the small roots produce many more plants to a bushel of seed than do larger potatoes. It would seem reasonable to believe that continued use of small seed would tend toward the production of a field crop of small tubers but this theory has not been substantiated in practice. The question has been raised whether, because the smaller potatoes are usually formed later in the season, the practice of using these small potatoes for seed would tend to produce a late strain. For all practical purposes, the tendency in this direction, if present at all, would be so slight as to be negligible. As the sprouts come only from the neck of the potato and as the greater number of smaller potatoes contained in a bushel provides a much larger total surface area from which the buds may grow out, it is quite evident that economy would result from the use of small tubers in so far as the number of plants produced is concerned. This fact is further augmented by the difficulty of disposing profitably of the small potatoes on the market for any other purpose than for seed. Although some growers maintain that more vigorous plants are produced from the larger tubers, more substantial evidence will have to be secured before discontinued use of the small tubers is warranted, especially if they are chosen from high yielding hills. It is probable that certain varieties have a greater tendency to produce stringy potatoes than do other kinds under the same conditions. It is evident that in case of a mechanical mixture of two such varieties, continued selection of the small tubers would result in the inferior variety becoming dominant over the more desirable one. As has been stated, however, the tubers

of different varieties should never be mixed. In general, it may be said that painstaking hill selection should be practiced in the fall at digging time, the potatoes selected being carefully saved in a storage-house and culled over in the spring. Medium-sized or small tubers are preferred.

Production of seed potatoes.

Some growers have adopted a systematic method of producing their seed stock with a view to the elimination of disease, improvement in quality and economy and convenience of growth without going through the entire field each year. One system is managed on the same principle as the "ear-to-row" test in seed-corn selection. A special seed patch is prepared. Medium-sized well-shaped potatoes are selected from high producing hills and enough are bedded to produce slips for the seed patch. The following year the same careful hill selection is made from the seed patch for tubers to bed for select plants the next year, the remainder of the seed-patch potatoes, whether from high yielding hills or not, being used to bed for the main field crop. This practice is probably justifiable when planting is done on a large scale and when wholesale selection of tubers for the entire field crop would have to be trusted in the hands of unreliable farm labor. The specialized production of seed stock from vines has been found of value, especially in the control of disease and in the better keeping quality of potatoes produced in this way.

Seed treatment.

Even though careful culling of bruised and diseased

potatoes has been practiced, much may be accomplished toward preventing trouble in the seed-bed by dipping the seed from five to eight minutes in a solution made by dissolving 1 ounce of corrosive sublimate in 8 gallons of water. (Fig. 6.) An old lard or molasses barrel may be used conveniently for the solution and the seed emersed in any convenient container which will permit the escape of the water back into the barrel. It is not necessary that the seed be rinsed in clean water before bedding. After treating three or four lots of seed, the solution should be discarded or more corrosive sublimate added. This treatment is designed to kill the disease spores on the surface rather than to reach those that may be present within a partly decayed tuber. Although having no effect on stem-rot, this treatment is helpful in controlling black-rot and soft-rot, if the tubers are not already affected. It has also been reported that soft-rot may be prevented by dipping the seed in equal parts of sulfur and air-slaked lime.[1]

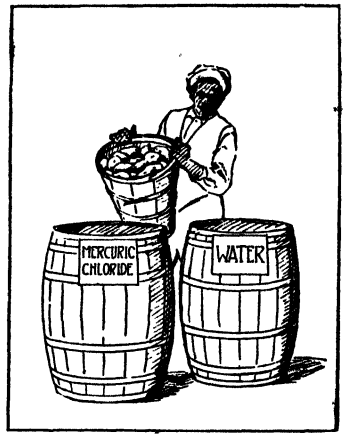


FIGURE 6.—Dipping sweet potato seed in mercuric-chloride 1:8 for eight minutes just before bedding.

[1] Report of the conference on sweet potato problems and on diseases of cotton, corn and tomatoes, Birmingham, Ala., Feb., 1919.

THE PLANT-BED

The kind of plant-bed to be used will depend on the area to be planted, climatic conditions and the facilities at hand for its preparation and operation. The growers of the Atlantic Coast area usually provide for one large sash or an area equal to about 32 square feet for each bushel of potatoes to be bedded. From 15 to 20 square feet of surface are required for a bushel of medium-sized tubers, while an equal amount of small roots will cover 25 to 30 square feet of bed, when they are placed as close together as possible without touching.

Location.

The first and one of the most important considerations demanded by the plant-bed is its location. No other one factor is so important as the choice of a good site. Especially is this true when strong plants are desired to provide the early crop. A high well-drained spot should be selected, and in the regions north of South Carolina a windbreak protecting the bed on the north is very desirable. In any case, cold windy places should be avoided, and unobstructed sunlight is essential. The southern or southeastern slope of a hill or a location protected on the north and northwest by thick woods or a large building is desirable. Where no natural protection is possible, growers often provide artificial windbreaks by the use of some thickly growing hedge such as privet or arbor-vitae thickly planted. In the more northern areas, a tight board fence is sometimes constructed around the bed, but usually when only sweet potatoes are grown, protection on the north side is sufficient.

The plant-bed will require frequent and careful attention and should be so situated as to be easily accessible at all times. Proximity to the field is not so important as nearness to the residence, as transportation of the plants is comparatively easy. Many large growers have found it convenient to provide a small shed where the plants may be placed temporarily in the shade while waiting to be carried to the field for planting.

Convenient watering facilities are an absolute necessity and this should be borne in mind when selecting the site. If the home place is located on a hill and the plant-bed is on lower ground nearby, a very convenient and economical watering system can often be provided by piping water from the home well to a barrel placed on a platform at the bed. When such a system is used, the water is convenient both for watering the bed and for filling the planter when it comes for a supply of plants. An open trough may often be used to convey the water instead of pipe when the former is more economical. Thoughtful care in locating the plant-bed will be repaid many times in profits received.

Preparation of the plant-bed.

The proper preparation of the plant-bed is very important for it is here in a comparatively small space that plants are to be produced to set the whole or a good part of the entire acreage. The plant-bed is the medium of a very intensive form of production. If the plants do not receive a good start in life, their growth will be greatly hampered. Therefore, no pains should be spared in preparing the plant-bed in the most thorough manner consistent with economy. The kind

of seed-bed to be used and the manner in which it is to be prepared will be governed very largely by prevailing climatic conditions, the number of plants to be produced and peculiar conditions that may be present in individual cases. In the Gulf states, plants are either grown in the open or in coldframes, while a little farther north hotbeds are employed quite extensively. These may be heated with decaying manure, a coal or wood furnace with flues running under the beds or with a hot-water system.

Open beds.

By far the greater number of sweet potato plants in the South are produced in open beds. Farmers who grow an acre or two for home use and who bed out a few bushels of seed instead of ordering their plants from a dealer, seldom go to the trouble to provide a permanent plant-bed of any kind. Nor would they be justified in so doing when such a small acreage is involved and since frequently the bed would be used for no other purpose than for the potatoes. Even when a considerable acreage is to be planted, the open bed method is often preferable in the more southern areas. Because of the longer growing period in this section, extra early plants are not always desired, consequently the seed may not be bedded until late when the ground has become sufficiently warm to make bottom heat unnecessary. The growing of plants in the open is very widely resorted to as being most consistent with convenience and economy.

The open bed must be so located as to allow thorough drainage. Although an excavation is usually desirable to provide room for the extra sand that is

added without raising the level of the bed too high above that of the surrounding ground, under no circumstances should the bed level be lower than the general land contour. The general practice is to make an excavation 5 or 6 inches deep, 5 or 6 feet wide and as long as is needed for the quantity of potatoes to be bedded. About 4 inches of clean sand is placed in this excavation. The tubers are put on top of this sand as close together as possible without touching, after which they are covered with 2 inches of sand. This bed is kept damp by sprinkling daily until the plants appear. As soon as the young shoots may be seen, another inch of sand should be added to insure the development of a vigorous root system. The importance of using pure sand in the seed-bed cannot be over-emphasized. The practice sometimes followed of placing the tubers on top of a thin layer of manure is unjustified. The sprouts grow from material stored in the potatoes and rich soil is not required. Not only is manure unnecessary (except in the sub-layer for bottom heat) but it is a carrier of disease. Pure sand about the potatoes is most certain to produce a large crop of strong, healthy, well-rooted plants. Such a bed may be covered with straw, hay or leaves to protect it from cold early in the season. Old burlap sacks are also sometimes used for this purpose. Such coverings may be valuable in preventing too rapid drying out of the surface.

Coldframes.

Some of the largest commercial plant-growers in the South and Southwest grow their slips in glass and canvas-covered coldframes. When potatoes are produced as an early truck crop, some means of protection so

as to allow earlier planting is necessary even in the region bordering the Gulf. The commercial growers are particularly desirous of producing early plants which bring the best prices, and in the lower South the coldframe answers this purpose. The location of the coldframe should be considered with the same care as for an open bed; Plate II shows a location well protected from cold winds by a natural forest windbreak.

Although coldframes may be constructed entirely above the ground or only partly so, the former method is usually employed because of convenience and thorough drainage which is afforded. (See Plate I.) Ordinarily a frame is made, using 14-inch boards on the north or west side and 8- or 10-inch boards on the south or east side, the ends being boxed up. The sides of the frame are held rigidly in place by cleats which are spaced at intervals of about 6 feet, the side boards being nailed to these. Brace-strips of 1 x 4 or 2 x 4 material extend from one side to the other at every place where the side boards are nailed to the cleats. If the bed is below the ground surface, the frame should, of course, be made to fit in the excavation. When built above the ground, the frame is hereby nailed together and set on the surface, being held rigidly to the ground by means of the cleats above mentioned which may be extended into the soil. Further protection from cold may be secured by banking dirt against the north side and the ends. The standard width for either a coldframe or hotbed is about 6 feet. The length will of course be determined entirely by the quantity of potatoes to be bedded. The coldframe is ordinarily covered with canvas (Plate I), although hotbed sash

are sometimes employed. The cross-brace pieces are more conveniently spaced every 3 feet if sash are used. They thereby act as supports for the sash and facilitate adjusting the ventilation.

Clean sand is used in the coldframe and the tubers are bedded just as in the open bed method.

Hotbed,— manure-heated.

The commercial sweet potato crop of this country is very largely grown from plants produced in hotbeds. This is because the states of New Jersey, Delaware, Maryland and Virginia, which at this time grow the greater part of the crop put on the market, have growing seasons too short to allow the plants to be started in coldframes; because of the increased price which the early crop brings; and the possibility of growing earlier plants in hotbeds than could be produced otherwise. The tubers are ordinarily bedded six to eight weeks before weather conditions permit the plants to be set in the field. In bedding so early, artificial bottom-heat is necessary to overcome outside temperatures and to obtain a quick growth of large stocky plants. Fresh rapidly fermenting horse-manure, which is naturally bulky and contains a large amount of organic matter capable of creating considerable heat in the process of decomposition, furnishes the cheapest and simplest method of supplying this bottom-heat. In preparing a hotbed, the frame is made in the same way as in constructing a coldframe, but an excavation must be made for the manure. The depth of the manure will be influenced by the severity of the temperature to be overcome and the length of time heat will be required. The depth usually ranges from 12 to 18 inches. It is better

to have the hotbed extend east and west as the sun-rays concentrated by the glass will be of substantial value in supplying heat. Sash-bars or cross-rafters to slide the sash on may or may not be used; if the walls are properly supported at the corners and at intervals along the sides by 2 x 4 inch stakes driven into the ground, cross rafters are not essential.

A layer of fresh horse-manure at least 12 inches deep is placed in the pit a week before bedding the potatoes and thoroughly packed by tramping. Manure which contains old sweet potato refuse or culls from the storage-house should be carefully avoided as diseases may be conveyed in this manner. Before using, the manure should be piled and forked over two or three times to insure uniformness throughout. In case the manure is dry, it should be watered, as moisture is an essential to the decomposition which produces heat. A layer of clean sand 3 or 4 inches deep is spread evenly over the manure as soon as heating starts. This sand should always be obtained fresh from the woods, a pit, or some place where it has had no chance to become infected with disease. Some of the most serious diseases develop in the plant-bed and every precaution should be taken against their introduction. Fresh sand should be used for bedding each season, as disease may remain in the sand and carry infection over until the next year. The woodwork of old beds should be sprayed each year as a precaution against disease.

After the bed has been prepared, it is best to place the sash in position and allow the heat to become constant before the seed are bedded. When the temperature has dropped to 80 or 85 degrees F., the tubers are

placed on the surface and covered with sand as has already been explained.

Hotbeds which are to be permanent are sometimes made of brick, stone or concrete, but growers generally prefer the cheap practical bed just described. This can be used for a few years and when demolished by decay the expense of building new is not so great as to offset the advantage of being able to move the bed at will.

Hotbed,— flue-heated.

In the more northern areas and where it is difficult to obtain a sufficient quantity of the proper kind of manure, heat for the hotbed may be secured from a stove or furnace through conduction pipes under the beds. The flue-heated bed may be constructed for one or two tiers of sash. When two tiers are used, they are elevated in the center and slope to each side. Hotbeds so equipped are frequently made of brick, stone or concrete as they are usually intended to be more or less permanent. However, a temporary structure may be made of wood. J. C. C. Price,[1] gives the following discussion on the construction of a flue-heated hotbed; "A flue-heated hot-bed may be constructed of concrete or boards for sides. The first is permanent, while the boards will rot out after a period of time. If the boards are treated with creosote they will last much longer. The frame should be located on a well-drained place, sloping to the south or southeast, so as to get the full benefit of the sun's rays and be protected from north and north-west winds. When possible, the frame

[1] Circ. 15, Ala. Exp. Sta.

is placed on a slight slope with the fire box at the lower end, thus giving the necessary slope to the floor.

"The fire box is constructed of brick and should be arched. The dimensions (as given in Fig. 7) are 18 inches wide (inside measurements), 20 inches high, and 4 feet and 8 inches long. The terra cotta flue pipe leading under the bed is 8 inches in diameter and should extend the entire length of the frame into the chimney at the other end. The first two or three joints of the flue should be covered with brick, as the blaze from the fire might cause it to become too hot and endanger the floor. The chimney may be made of brick or by nailing together four 12-inch boards in box fashion. The chimney should be larger than the flue under the floor as it will draw better.

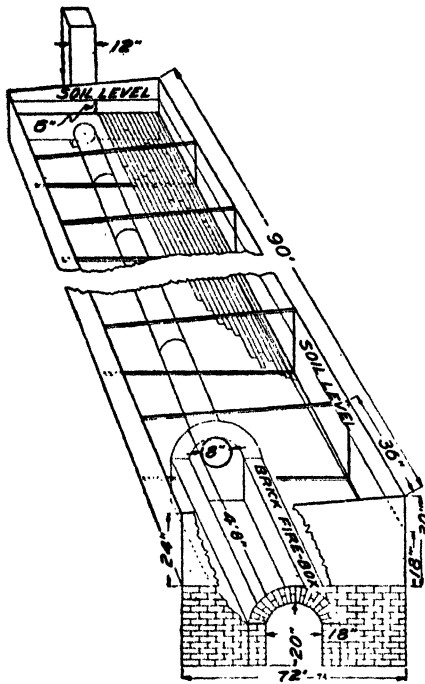


FIGURE 7.— Showing the construction of a fire-heated draw bed.

"The wooden floor should be built at least four inches above the flue, so as not to catch fire and to give better distribution of heat. The floor should have a slope of one inch to seven and one-half feet, or twelve inches in ninety feet. That is, the soil at the furnace end should be eighteen inches deep and at the chimney end six inches deep. The flue under the floor should have the same slope as the floor. The soil on top of the frame should be level. Any kind of rough boards may be used as flooring. They should be treated with creosote to make them more durable.

"As shown in the drawing, the frame should slope toward the sun and should be six inches higher on the back than on the front side. The top of the frame should be level from east to west."

Hotbed,— pipe-heated.

A type of hotbed rapidly gaining in favor among the commercial plant-growers of the northern areas is one heated by means of hot water or steam pipe lines, which may be supplied from a greenhouse boiler or a separate heating furnace. The lines of pipe are commonly laid 4 or 5 inches below the bed surface. Miller [1] describes the method as follows: "Where a steam or hot-water boiler is used for heating a greenhouse, residence or other structure, it can often be employed to good advantage in heating the sweet potato bed. In fact, where sweet potato plants are grown on a very large scale it might be advisable to install hot water or steam heat even if it is not used for other purposes. The temperature of the bed can be regulated more easily where

[1] Farmers' Bull. 999, U. S. Dept. Agr., page 11.

steam or hot water is employed than where other methods of supplying heat are used.

"When steam or hot-water pipes are used to heat the hotbed, the best results are secured when the pipes are placed near the bottom of the hotbed pit, the soil being put on a tile or board floor resting on pipe or wooden supports so as to leave a space of a few inches between the bottom of the pit and the floor. The number and size of the heating pipes required depend on the rapidity of the circulation and on the temperature of the water or the pressure of the steam. When hot water is used, four 1½-inch pipes will be ample in most cases for beds not over 50 feet long. For larger beds 2-inch pipes should be used. Two of the pipes serve as flow pipes and two as returns. The water enters at one end, makes the circuit of the bed, and leaves at the same end. The point where the pipes enter the bed should be the highest in the system, and the point where the pipes leave the bed the lowest in the system. The pipes should have a uniform grade and should be evenly spaced, with the flow pipes about a foot from each outside wall and the returns in the middle. When steam is employed the arrangement of the bed and pipes is the same, but smaller pipes may be used. With steam at 10 pounds pressure 1-inch pipes are large enough for 50-foot beds, and 1¼-inch pipes are ample for beds up to 100 feet long."

A general idea of the construction of a pipe-heated bed may be gained from Fig. 7. The same rules governing greenhouse heating apply to piping beds of this kind.

Other types of hotbeds.

In the absence of stable manure and when the size of the bed is not enough to justify the installation of one of the more elaborate heating systems just discussed, other simpler heat-producing materials may be employed. A moderate hotbed may be heated by means of oak leaves, damp with fresh lime sprinkled through them as they are packed in the excavation (which should be at least 2 feet deep) under the frame. Such beds will produce moderate heat and will hold it longer than stable manure. An ordinary cotton cloth may be used for a cover. Many growers use no cloth or glass, but often cover thickly with pine straw, raking it off on warm sunny days and covering again at night. Pine straw and mold have been used for bottom-heat but they are of practically no value.

Bedding.

In regions as far north as New Jersey and New York, bedding is not ordinarily done before April 1st to 10th, while in the lower South the seed may be bedded in early March. A bed 100 feet long and 6 feet wide should furnish enough plants to set six acres at the first drawing and enough for three acres more ten days later. It will require about 35 bushels of average seed for a bed this size. The sand in the bed should be at a temperature of about 85 degrees F. at the time of bedding, and should be allowed to drop slowly to 70 degrees F. A minimum temperature of 60 degrees F. should be maintained during the entire bedding season. The seed should be handled carefully and not allowed to

chill in moving from storage to the newly prepared bed. For convenience, burlap-lined baskets should be used and bedding is preferably done on a warm bright day. The seed should be carefully examined for disease and all suspicious tubers discarded. All the seed should receive the corrosive sublimate treatment already described. (Page 61.) After draining, the tubers are carefully laid by hand as closely together on the bed surface as possible without having them touch. (Plate I.) If the potatoes are crowded in the bed, disease may be spread from one tuber to another and the sprouts will be so crowded that long spindling plants will be produced. If unusually large roots are employed for seed, they may be split lengthwise and placed with the cut side down in the bed. Many growers have found that a thin layer of pine needles placed over the potatoes before the sand is applied aids materially in holding the tubers in place when the plants are pulled. Only part of the top sand should be applied when bedded, for if the tubers are covered too deeply some rotting may result. Ordinarily about 2 inches of sand is applied when bedded and an additional inch put on after the shoots appear. The covering sand should be evenly distributed, carefully smoothed and lightly packed by planking. Only clean fresh sand should be employed. As has been stated, sand is as good as rich soil for the sprouts come from the material stored in the potato. However, the use of sawdust should be avoided. After the bed has been completed, it should at once be wet thoroughly with a fine spray from the hose or with a sprinkling-can.

Covering for seed-beds.

Some kind of covering, if not always essential, is desirable for the protection of the young plants from cold nights and from the cool temperatures that often occur late in the season.

With a moderate hotbed, sweet potato plants can be grown under cloth as well as glass. Many growers, from South Carolina and Tennessee southward, use no other cover than pine straw, which is raked off in the daytime after the plants are started and replaced at night. If the nights are cool, pine straw is frequently employed to cover the beds before the plants appear.

The ordinary hotbed frame may be covered with cotton twilled cloth. The kind of covering may materially influence the type of seed-bed to be employed. In regions south of North Carolina, light bottom-heat is often needed when a cloth covering is used, while in the same territory no bottom-heat may be required if glass sash is employed and properly managed. When cotton cloth is used, it should be treated with hot linseed oil to render it waterproof and to lengthen its usefulness by preventing decay. Canvas covers should be tacked on one side and provided with poles on which they can be rolled up in the daytime to admit sunlight and secure ventilation. Handling the cloth cover will be greatly facilitated by providing support lathes or wires at frequent intervals. Such construction will cause the water to drain off without forming puddles and dripping on the bed. In Texas, Oklahoma and Louisiana, commercial plant-growers frequently use coldframes, 6 feet wide, constructed of 8-inch strips for the sides. A thin cotton cloth is merely tacked over this flat bed and only re-

moved about once a week, the watering being done by sprinkling on top of the cloth. These coverings are so thin that considerable sunlight is given the plants without moving the cover. In these warm sections, this practice seems satisfactory although the cloth covers seldom last more than one season. If good canvas is used and properly oiled and cared for, it may last several years and makes a suitable covering even for the hotbeds as far north as Virginia.

Glazed hotbed sash are more commonly used as coverings in the northern part of the sweet potato district, for both manure and fire-heated beds. The regular 3 × 6 foot sash is commonly employed. A cheap home-made sash is sometimes built by the use of scrap glass and suitable strips of lumber. Johnson and Rosa [1] describe these home-made sash as having, "six rows of small panes of glass, supported on wide strips. These obstruct a large part of the light, which, however, is not a serious objection with sweet potatoes. These sash are cheap and if well made answer the purpose." Sash, when used, should slope toward the south or east, if the greatest benefit is to be derived from the sunlight. If carefully handled to avoid breakage and the wooden parts are painted each year, hotbed sash will last for many seasons and will in the end prove to be cheaper than cloth coverings. As they are always useful in any garden for producing all kinds of young plants early in the season, sash are perhaps the most popular among growers for the sweet potato plant-bed.

A board covering is sometimes used but because of the difficulty involved in handling and its inability to admit sunlight, it is undesirable.

[1] Bull. 19, Va. Truck Exp. Sta., page 396.

Care of the plant-bed.

When the plant-bed has been placed in an ideal location, the bottom-heat perfectly regulated, the top soil or sand carefully selected and applied for its purity and freedom from disease, and the tubers which have been carefully selected and treated for disease are evenly placed in the bed and covered, the task of producing strong vigorous plants which will vitally influence the crop yield is only half accomplished. A sweet potato plant-bed may be perfectly prepared but unless properly cared for discouraging results will be the consequence.

Maintaining temperature.— As has been stated, the temperature of the plant-bed should be between 80 and 90 degrees F. or around 85 degrees F. when the tubers are bedded. This heat should be allowed to decrease gradually until a constant uniform temperature of 70 to 75 degrees is reached at the end of about six weeks. In no case should the temperature be allowed to go below 60 degrees F. as it is sure to cause injury to the growing shoots. The temperature of the bed should be noticed carefully every day for the first ten days. A thermometer should be kept continually in the soil. In these first few days a manure-heated bed may suffer considerable variation in temperature which will require regulating. In case the bed is not well drained, excess water may find its way into the manure, destroying the heat altogether or starting a new fermentation resulting in the production of heat too intense for the well-being of the young sprouting buds. In case of extreme heat, enough water should be applied thoroughly to wet the surface sand. A double row of 3-inch holes, 1 foot apart, should then be worked along

the center of the bed through to the manure. This may be done by using a crowbar which is pushed into the ground and then removed. Such an operation, aided by the removal of any covering, will rapidly lower the temperature of the bed. It nearly always happens that after a few days some parts of the bed will become too hot and other parts too cold. The cooler places should have the sash left over them during the heat of the day so that the sun's rays may be concentrated on them while the hotter places may be shaded. Even though a thermometer is not used, an experienced grower carefully examines all parts of the beds every day by thrusting his finger into the sand between the potatoes and below their level. If a comfortably warm temperature can be maintained at this point, it is satisfactory.

Watering.— Water should be applied abundantly as soon as the potatoes are bedded. After this the bed should be liberally watered two or three times each week until the plants begin to form leaves. After the leaves form, the bed will need water every day. It is best to water the bed about three or four o'clock in the afternoon so that the surface of the soil and leaves will dry off before night. If this is done, no trouble will be experienced from the damping-off fungi. The method of heating will in a measure influence the amount of water necessary. A steam- or furnace-heated hotbed will require more water than will an ordinary manure-heated bed. Water should always be applied in a spray rather than in a solid stream. This may be accomplished by means of a sprinkling-can, with the spray-nozzle on the hose or by means of regulating the spray with the hand as it comes from the hose without any nozzle. Many growers prefer regulating the water in the latter way,

claiming they can better place it where desired. Small growers who have seed-beds in the garden sometimes prefer to use lukewarm water containing soap-suds on their plants. The wash-water from the house is commonly saved for this purpose. The merit of this practice seems to be questionable. At all events, it is impracticable and undesirable for the planter with more extensive beds. Ordinarily the beds may be allowed to take all rains.

Hardening-off.— It is recommended that the sprouts be allowed to reach a height of 4 to 5 inches above the surface of the sand before they are removed. A "hardening-off" process lasting a week or more, during which the ventilation is increased and the water supply shut off, should be employed before transplanting. This process must be brought on gradually as the time for drawing approaches. Toward the end of the period in which the plants are to remain in the bed, the ventilation should be increased by leaving off the cover entirely during the warm part of the day and even in the early morning and late evening considerable more ventilation can be given. When removed entirely, which is advisable during the last few days before the plants are pulled, the cover should be kept close at hand where it can be put on quickly in case of a late cold spell. Sweet potatoes are very sensitive to frost and even though they have been accustomed to the air, the slightest frosting will cause serious injury.

Treatment of seed-bed for disease.— Disease may often appear in the plant-bed after the tubers have been bedded, especially if they have not received the corrosive sublimate treatment already discussed. W. F. Massey recommends spraying the bed with bordeaux

mixture in such cases, for the purpose of killing some of the causal fungi which may be present. However, prevention is far easier and more reliable.

DRAWING THE PLANTS

Sweet potato plants should not be set in the field until after all danger of frost is past. The plants will ordinarily be ready for drawing five weeks after the hotbed has been put down, although seven or eight weeks are sometimes required for plants to reach proper development in a coldframe or open bed. The ground for planting should be ready and the plants promptly pulled when they are 5 to 6 inches high. The common practice of waiting for a rain to transplant is unnecessary if one-half pint of water is applied to each plant when set. In fact, many growers claim the plants grow off better when set in this way.

The plants should be drawn carefully one at a time. If the roots of several plants are grown together, they should be separated at the bed to avoid delay in the field. Drawing should be done by giving the plant a sidewise pull with the right hand while the left hand is employed in holding the ground firmly to prevent the mother potato from being disturbed or drawn up. As the plants are pulled, they should be placed in baskets or crates and covered with a burlap sack or with hay to prevent drying out while being carried to the field. It will often be convenient to have a small shed at the bed in which the plants may be stored with roots down until needed in the field. Many commercial plant-growers have a special shed for this purpose which is provided with a shallow pit in which the bundles of plants (100 or 200 in a bundle) may be stacked with the roots in

soft damp soil or a bed of saturated moss until they can be packed and shipped out. The plants do not develop uniformly, and in pulling many small plants must be left for further growth. A well-developed root system is very desirable and if the bed has been properly prepared with sand no difficulty will be experienced in this regard. Much time may be saved in the field if the plants are orderly and systematically handled at the plant-bed. All roots should be turned in the same direction and if a machine is used for transplanting, it will often be necessary to trim off long or irregular tops with a knife. It is essential that draws planted by machine be in the best possible condition if they are to be efficiently handled by the boys who sit on the back and feed the plants into the machine. Nimbleness is necessary under the best of conditions and if the plants are irregularly arranged and grown together, many skips in the field will be the result.

In very dry weather or when a small area is to be set by hand-dropping the plants, growers sometimes have at hand a large tub containing a mixture of an equal part of clay and cow-manure mixed to the consistency of a thin slime with water. As the plants are pulled from the bed, they may be taken in small bunches and their roots dipped into this mixture. This "puddling" process, though of some value, is now seldom used because of the disagreeable feature of handling the plants with mud-covered roots. The plants should never be allowed to stand in such a mixture for any length of time, as they will shed their leaves.

In preparing plants for shipment, commercial growers usually tie them in bundles of 200 each with soft cotton twine. Perhaps the most economical method of

packing is in a burlap bag which has been split open and cut in half or for large bundles left whole. The sack is first split and laid on the ground or packing-table, placing on it an old newspaper which has been dampened with water. The bundles of plants are then placed roots down on top of the wet paper, putting them in a circle with a bundle in the center. A second and even a third layer of bundles of plants may be placed on top of the first. Each succeeding layer should contain fewer bundles than the first, thus building the pile up into a compact cone-shape. The package is tied by bringing the corners of the sack together in the center, much as a bundle of clothes would be tied in a sheet. Although the roots need moisture, the tops had best be kept dry. When packed in crates or baskets, damp moss is frequently placed around the roots. From 2000 to 4000 plants can ordinarily be packed in an average size burlap bag which has been split open and the plants arranged as described above. When in crates or baskets, the plants are perhaps not bruised so much as when packed in burlap.

USE OF VINE-CUTTINGS

The value of vine-cuttings in the control of certain diseases is now universally recognized throughout the sweet potato area. When vines are cut from the growing plants and transplanted in new fields free of disease, the potatoes produced will be disease-free. Practical growers have long since discovered the value of this means of propagation in the eradication of black-rot. For this reason, vines or "vine-cuttings" are widely used in producing tubers which are to be employed for

seed. Most sweet potato authorities now advocate growing seed from vine-cuttings. The potatoes grown from vines are not only practically free from disease but they seem to keep better in storage and are about the proper size for seed. Frequently the main crop is grown from vine-cuttings, only enough sets being planted to produce vines sufficient to set the required acreage. This practice is not only satisfactory in so-far as disease control is concerned, but is more economical than purchasing or raising enough plants for the entire acreage. When a machine is employed for setting such plants, all or most of the leaves must be stripped from the cuttings to facilitate handling. The cuttings are made as soon as the vines are 3 or 4 feet long. Pieces 7 or 8 inches long containing about two joints are commonly used. These cuttings are usually made from the early vines grown from slips. Setting and handling is done the same as with slips. It is generally conceded by growers that after the vines have begun to run well, the use of vine-cuttings is much to be preferred to the slips, especially for the late crop. However, except for the advantages already mentioned, experiments have shown practically no difference in yield. It has been found that too close pruning of the vines will decrease the yield of marketable potatoes by increasing the percentage of smaller ones.[1]

The effect of constant propagation by vine-cuttings and the influence on yield of constant selection of cuttings from plants with the most vigorously growing vines are problems yet undetermined. Individual plants of the same variety growing side by side often

[1] G. W. Carver, Bull. 30, p. 7, Tuskegee Normal and Ind. Inst.

show wide variation in hardiness, thrift and vigorousness of growth. It would seem reasonable to believe that continued selection of vine-cuttings from the best individual plants would in time give favorable results in the offspring. Vine-cuttings seem to be especially popular for the very late crop. Fitz [1] cites a Georgia planter who with vine-cuttings planted July 18, which were given one hoeing and one plowing, produced a yield of 125 bushels to the acre, more than half of which were marketable potatoes.

When planted especially for the production of seed potatoes, the vines are usually not set until July or the first of August. This late planting gives a good yield of small tubers which are easier to keep than potatoes from the earlier plants. It is preferable to plant out vine-cuttings just after a rain while the soil is wet, but if enough water is used they may be planted in dry weather about as successfully as draws under the same conditions.

E. A. Miller [2] has given the following directions for storing sweet potato vines which he says has been used quite successfully in some western sections: "Take four boards, about eight inches wide, drill them full of holes and then nail them together to form a hollow flue. Set these up endwise in some protected place in such a manner as to form a flue, and then place the sweet potato vines around this flue, cover with straw and bank up around it with earth, to protect them from cold. The flue will permit a free circulation of air which will keep the vines alive through the winter."

[1] Jas. Fitz, "Sweet Potato Culture," page 73.

[2] Formerly specialist in potato storage of the Extension Service, Tex. A. & M. Coll.

THE COMMERCIAL PLANT BUSINESS

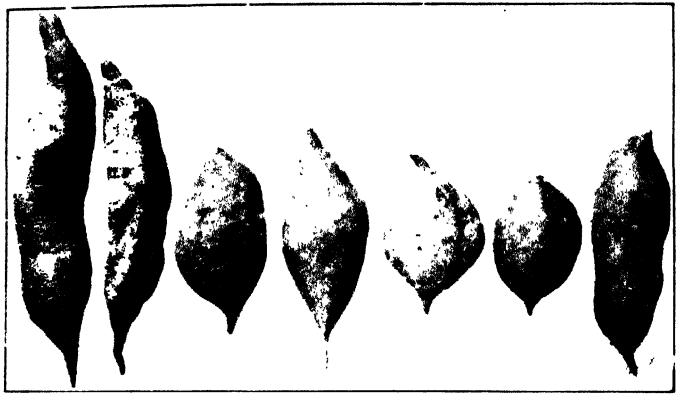
In recent years there has been a large demand for sweet potato plants of pure varieties which are free from disease. The greater part of the sweet potato crop in the South is raised by small farmers who produce just enough for home use and possibly a few to sell on the local markets. These growers usually prefer to buy a new supply of seed or plants each year for their small area. Recently a number of large sweet potato storage companies have been formed for the purpose of producing, buying and storing the crop. These organizations require large supplies of plants to set their new area. These conditions and the continually increasing interest which has been taken in sweet potato production in recent years have given rise to the development of a number of commercial plant industries.

Two months will cover the time required to produce salable plants from seed. As a bushel of seed which can ordinarily be bought for $2.00 or less will produce from 2,000 to 4,000 plants worth as much a thousand as the original bushel of seed cost, there is opportunity to realize a good margin of profit in a comparatively short time if proper care is exercised. Often heavy rains will prevent the beds from "slipping" just at the season when the plants are most in demand, while later on an abundance of plants may be produced which cannot be disposed of on the later market. However, since some growers bed 10,000 bushels or more seed, assuming the risk of their disposal, it is evidence that the business can be made to pay if properly handled and unfortunate occurrences do not interfere.

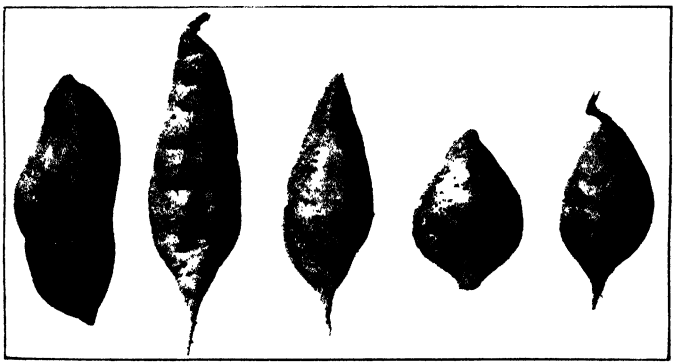
Field methods.

The commercial plant-grower ordinarily employs either coldframes or flue-heated or pipe-heated hotbeds, the former in the southern and southwestern areas and the latter farther north. Cloth covers are used on the coldframes commonly and the beds are prepared as described for ordinary coldframes. (See page 66.) An adequate supply of water must be provided by piping and hose connections, by running one or two pipes through the area covered by beds on which are numerous faucets for hose attachment. Men must be kept busy continually, providing for the proper moisture requirements of the beds.

Drawing of the slips is done by negro women and girls who may be employed at a relatively low figure and can accomplish work satisfactorily. The slips are pulled and placed in piles, 200 plants to each pile. One or more of the hands is kept busy tying these bundles and putting them into containers to be transported to the packing-shed. A superintendent is necessary to see that the drawing is done carefully and that the counting is correct. At the packing-shed the plants are received by the packer in charge who stacks them roots down and one layer deep in a shallow pit, the bottom of which is covered with damp moss, the different varieties of course being kept separate. The packer will find it convenient to work on a low platform on which the plants are packed in sacks, crates or boxes. To his right and above the packing platform is a roughly constructed board desk on which is kept in plain view the order-sheet, the corresponding shipping tags and miscellaneous supplies. Hanging over the packing platform is a



a *b* *c* *d* *e* *f* *g*



a *b* *c* *d* *e*

PLATE IV.— Varieties of sweet potatoes. *Top:* Typical specimens of some of the commercial moist-fleshed varieties of sweet potatoes: *a*, Yellow Belmont; *b*, Pumpkin; *c*, Porto Rico; *d*, Nancy Hall; *e*, Southern Queen; *f*, Dooley; *g*, Bunch. *Bottom:* Some of the important commercial dry-fleshed varieties of sweet potatoes: *a*, Big Stem Jersey; *b*, Triumph; *c*, Yellow Jersey; *d*, Yellow Jersey; *e*, Red Jersey. Note the two distinct types of the Yellow Jersey variety.

roll of soft cotton twine which is used for tying the plants and for tagging. This twine can be purchased in rolls of about fifty pounds each which are so made that they can be suspended on a stick placed through the center and unrolled as needed. The order-sheet is made out at the office by the owner or his bookkeeper. This sheet includes the purchaser's name and address and the variety and number of plants desired. Shipping tags are made out to correspond to each order and sent down with them by the bookkeeper. No bookkeeping is done at the packing-shed. The order sheet is kept in convenient reach at the packer's right and as the orders are filled and tags attached to the packages, they are checked off the list. The work thus proceeds systematically and without confusion and lost motion.

Office methods.

If the grower is sufficiently well known throughout the territory which he supplies or desires to supply, and his stock has been properly advertised, the office force will be well occupied from the middle of April until July 1st. Many orders will be booked during the winter and early spring months and these will be tabulated for immediate attention when the first plants are ready to be drawn. A rush of orders will, however, begin to pile in with the beginning of early planting season and at this time the grower receives the best prices for his plants. These orders must receive prompt attention. Nothing is so valuable to a commercial grower as to have the reputation of giving his orders prompt and faithful attention. Many telephone and telegraph orders will be received by the progressive grower and these must be given the same courteous attention as the mail orders.

The business-like plant-dealer never sends a customer one variety of plant when another has been ordered without first asking whether the substitution is satisfactory. The very best business principles must be used in the office if satisfied customers are to be gained.

The office force tabulates each order by making an order sheet in duplicate. One copy of this order-sheet is sent to the man in charge of the packing-shed together with corresponding shipping tags. One system of handling money must be adopted and rigidly adhered to. It is best that all orders go through the office in the regular prescribed way, and no plants sold directly from the beds without making a record of same. Of course the particular system to be used will be worked out in each case by the owner in such a manner as to fit his specific conditions. As with any other business, there are many possible "leaks" that must be avoided if profit is to result.

Advertising.

Although a dealer may be able to grow the most perfect plants at the proper time and season and with a minimum cost for production, unless he can dispose of them at a profitable price, his enterprise is a failure. It should not be concluded that advertising in its proper sense can be done in any one year or two years and through newspapers and farm journals alone. Any broadly successful business is gradually built up through long years of earnest and concerted effort, by fair dealing always and with the continued aid of the printed announcement. A satisfied customer is the best advertisement. The classified ad columns of the leading farm weeklies seem to be one of the most popular and

efficient advertising mediums. Some growers have found that large and more attractive advertisements in a few leading daily papers having a wide circulation are highly profitable. Small and less expensive advertisements should be run during the late winter and early spring months, announcing the varieties offered and the prices booked for delivery at a specified time. For a few weeks before the rush season opens, it will be profitable to run a good advertisement in every daily or weekly paper published in the immediate vicinity. At this time more than at any other, the advertising campaign should be pushed.

CHAPTER V

TILLAGE, FERTILIZING AND ROTATION

THE soil adapted to sweet potato culture is usually easy to prepare, in about the same way as for corn or cotton. It should always be borne in mind that very thorough preparation is repaid in the case of cultivation to follow. The depth of cultivation has considerable influence on the character of the product.

If the soil has not been broken deeply before, a little more should be plowed each succeeding year rather than the entire depth the first year. The land may first be prepared either by flat breaking or by ridges thrown up to form rows. It is important that the land should be harrowed within a few hours after plowing. It should be thoroughly pulverized, and this may be done shortly after a shower while the lumps and clods are still soft. After this work has been completed, the soil should be mellow to a depth of 6 to 8 inches, and the surface smooth and even.

Preparation for planting.

After the land has been plowed and fitted for the sweet potato crop, it should be allowed to lie idle several days before planting. If potatoes are to be planted flat for level culture, only a harrow and a marker are necessary for planting. The harrow should be run both ways and the surface thoroughly pulverized. The

marking may be done either with a one-horse roller rake-toothed marker or a disk-marker. When the more universal ridge method is used, the ridges or rows are made by means of a turning plow or disk. The ridges should be turned a few days before planting in order that the soil may have time to settle. Most farmers make the ridges whenever the land is in working condition, and then run over them with a drag or roller to level them, and leave a suitable place to set out the plants. By means of the roller or drag, from four to eight rows can be done at once, according to the nature of the machine. A drag can be built at home by nailing together several pieces of 2 × 4, or one or two 4 × 4 scantlings.

In small patches for home use, ridges are often leveled by means of a field or garden hoe, all the preparatory work and cultivation being done by a one-horse plow.

Distance and method of planting. (See Plate III.)

When level culture is practiced, plants may be set from 24 to 30 inches apart in each direction. On the eastern shore of Virginia, Delaware and New Jersey, a part of the crop is checked 24 inches each way, therefore requiring about 11,000 plants to the acre. When the crop is grown in ridges, it is customary to have them from 30 to 40 inches apart, and the plants from 12 to 18 inches in the row. By this method an acre will require from 8000 to 12,500 plants, the average acre throughout the Gulf Coast region being set with about 10,000 plants.

In planting for level cultivation, the location for the plants is indicated by cross marks made by running the marker in two directions across the field, the marker being at right angles. When planting on ridges, the

distance of the plants apart may be found by running the marker across the rows.

An important operation to be watched is the proper setting out of the plants after they have been drawn from the seed-bed. It is a common custom throughout the sweet potato region to set just before a rain or as soon thereafter as the land will permit. It is essential to have the roots in contact with moisture, and the soil packed firmly around the plants. If the ground is not wet, it may be necessary to haul water to the field and pour about one-half pint around each plant.

In the area where irrigation is practiced, the plants may be set and the water turned on which will insure the growth of practically all the plants.

Setting the plants in the field.

When only an acre or two is grown for home use, hand-planting will answer the purpose and is probably more economical. A trowel and dibble may be used to open and pack the earth around the roots; after the roots of the plants are thrust into the hole in the ridge, the earth should be pressed firmly around them. For hand-planting, plants are dropped ahead of the setters, boys and girls being very useful for this work.

Setting out one acre by hand is considered a good day's work for one man. A part of the undesirable work by hand may be avoided by the use of tongs. After the plants have been dropped on the rows, the root may be clamped with the jaws of the tongs and thrust into the ground. This saves the bending of the back and is practically as fast as the hand work. The tongs should be of wood and about 3 feet in length; the jaws of the tongs should be made by sawing out a por-

tion down through the middle of the stick. This will leave jaws on either side that stand erect but are readily clasped together. On being released from the hand, they assume their natural position. An instrument known as a shovel or punch may sometimes be used. This may be made from a narrow board with the ends somewhat sharpened, with which a hole is punched, the root inserted in the hole and the ground packed around it.

When a large acreage is planted, hand-setting is too slow and expensive, and transplanting machines are used which are capable of setting several acres of plants in a day. With these machines it is not necessary to wait for a rain, as they automatically throw a small quantity of water around the roots of each plant as it is being set. These machines will set from three to five acres a day.

Cultivation. (Figs. 8–11.)

After the potato plants are set in the field, ordinary

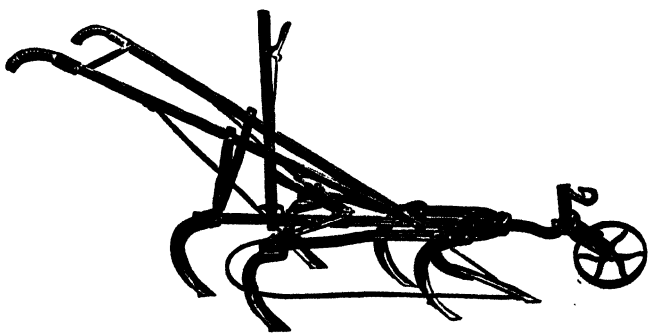


FIGURE 8.— Five-tooth cultivator.

methods employed for other crops are all that are necessary for sweet potato cultivation. In the South it is customary to keep the weeds and grass from the row by

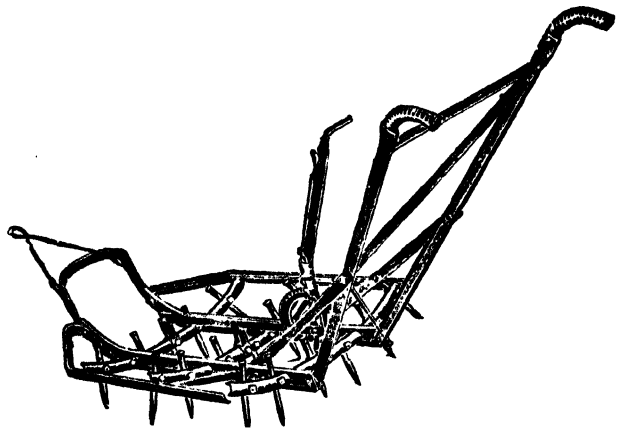


FIGURE 9.— Mulch harrow.

giving at least one hoeing. The potatoes are plowed two or three times or until the ground is covered by the vines. Cultivation should cease when the vines have thoroughly covered the ground. In the small patches and fields, the one-horse plow or cultivator is ordinarily used, or sometimes the spring-toothed harrow.

In flat lands on the coast where the soil is wet, farmers often use a plow to throw up a high ridge. While this assists in drainage, it is not thought to be of much value from the standpoint of cultivation.

On larger farms where potatoes are grown for commercial purposes, cultivation is done by one- and two-horse cultivators. In this way a row is completed at

FIGURE 10.— Diverse spring-tooth cultivator.

one passage over the row, practically the same kind of plows being used as on the single-stock plow.

It is customary in certain localities to throw two rows of vines to the same middle and cultivate the alternate middles thus left free or clean. In some sections the vines are turned from one side of the row to the

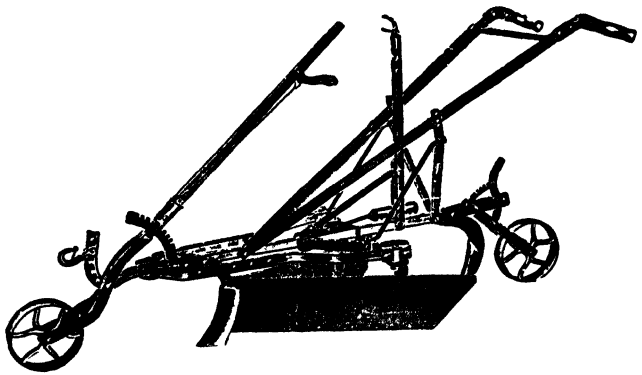


FIGURE 11.— Five-tooth cultivator with banker attachment.

other while plowing, then turned back after the plowing is finished. It is not thought advisable to turn vines after the ground is thoroughly covered. After the vines have become large enough to shade the ground, the shade will kill out grass and weeds and keep the surface cool; it is not necessary to cultivate later than this.

Irrigation.

In some arid regions where sweet potatoes are grown, it is necessary to supply moisture by means of irrigation. The most practical method is the open ditch, or furrow irrigation with water, the supply coming from some stream or lake. The greatest quantity of water should be supplied between the time the plants are set in the field and when the vines thoroughly cover the ground. Too much water applied during the latter part of the summer or after the vines have covered the ground may result in an excessive growth and a small yield of stringy potatoes. It is preferable that the water be given at evening or on cloudy days. For some time before harvesting, water should be withheld altogether in order that the roots may properly ripen and mature.

FERTILIZERS

Manure is the foundation of successful agriculture.[1] Any substance added to the soil to render it more fertile may properly be termed a fertilizer or a manure. The successful producer of sweet potatoes or of any other food plant secures crops that command a selling price in advance or in excess of their production cost

[1] Miller, Farmers' Bull. 999.

and at the same time maintains or even increases the productivity of the soil. A most important factor in the determination of profits which must necessarily be considered by the business farmer of to-day is the relation of the annual outgoing and incoming of plant-food. Sound business principles do not warrant the production of increased crops unless they can be grown at a genuine profit, which embodies more than a margin over and above the production cost in the way of manures and labor and should take into account the permanent effect on the productive power of the soil. These facts have been realized in a practical way, perhaps without any special understanding of the scientific principles involved, by many of the sweet potato growers in the commercial producton centers. This is especially true of the New Jersey, Delaware and Virginia growers who have by many years of practical production and observation learned that diligence must be exercised in the rotation of crops and the annual application of manures if the quality of their "Nansemond sweets" is to meet the expectation of discriminating markets and the productivity of their land is to be maintained. In areas where this practical observation has not been facilitated by systematic commercial production, a vast improvement in the proper manuring of the sweet potato crop must be effected by producers if they are to compete successfully with their more experienced neighbors. This phase of production is of especial importance to the naturally favored areas of the cut-over pine-belt, and on the depleted cotton and tobacco farms of the South where the prevailing climate and soil conditions aided by intelligent and judicious use of the proper manures would make

possible enormous yields of a high-class quality product.

Although fertilizers have become a necessity in the production of the sweet potato when maximum profit is derived, certain kinds of manures may result in actual injury to the quality and so reduce the selling value as to make the crop unprofitable. Some soils may yield profitably to the application of one food element while another may actually retard productive growth. For example, it has been found that liberal application of a fertilizer rich in potash and in phosphorous is especially profitable on a soil filled with undecayed organic matter such as one that has had a green-manure crop turned under, while a heavy application of a nitrogenous fertilizer on such a soil might result in the growth of very luxuriant vines with practically no production of tubers. It is now believed that applications of potash on certain red clay soils of the South, although causing increased yield, do not produce an increase sufficient to warrant its use, notwithstanding that the sweet potato makes heavy demands on the potash-content of the soil. Although the sweet potato responds readily to additions of organic matter to the soil, such as the liberal use of green-manures and barnyard fertilizers, these materials cannot be applied directly to the crop without reducing the quality and selling value but can best be supplied to the crop immediately preceding the potatoes. It is now concluded that nitrogen can, other things being equal, be supplied most economically in some organic form, such as cotton-seed meal, rather than nitrate of soda or sulfate of ammonia.

To understand the proper manuring of a crop of sweet potatoes and the fertilizer requirements of a given rotation, a few fundamental principles involved in

fertilizer standards must be studied, the forms of plant-food required, the sources of supply, as well as present day methods of preparation, commercial sale and application.

Kinds of fertilizers.

Fertilizers may be direct or indirect; complete or incomplete. A fertilizer that supplies available plant-foods directly to the soil is known as direct. Nitrate of soda is a good example of this type.

A fertilizer that benefits growth through its effects on the availability of the plant-food already contained in the soil, through its action on soil acidity or by improving the mechanical condition of the soil, is known as indirect. Strictly in this sense, drainage, proper culture or humus might be considered fertilizers. Lime is the most commonly used commercial fertilizer of the indirect type.

Although plants ordinarily require about fourteen different food elements for their normal growth, only four and usually only three ever need be applied artificially. These three are nitrogen, phosphorus and potassium; the fourth is calcium in the form of lime. A complete fertilizer is one containing nitrogen, phosphorus and potash while an incomplete one supplies only two of these plant-foods.

Function and form of plant-foods.

Nitrogen, phosphorus and potassium are known as the "essential" fertilizing constituents since they are the specific plant-foods most likely to be deficient in soils or more quickly exhausted by the production and removal of crops. Nitrogen functions most largely in

the production of vegetable growth. A soil overly rich in nitrogen tends to produce an excess growth of vines at the expense of the roots. Phosphorus and potash, while present in the vine growth and more or less essential to it, function more largely in the make-up of the edible roots, and in the case of other crops in the formation of fruit or seed.

Nitrogen, which in commerce is the most expensive of the "essential" elements, exists in three distinct forms; as organic matter, as ammonia and as nitrate.

Organic nitrogen occurs in all plant and animal forms and its availability as plant-food depends entirely on the rapidity with which the various forms decay. In any case, its availability as plant-food comes about more slowly than the two other forms of occurrence, as nitrate or as ammonia. The organic forms furnish some of the more valuable sources of nitrogen and are of value where the more quickly available forms would be of relatively little importance. Cotton-seed meal, dried blood, fish scrap and tankage are valuable commercial sources of organic nitrogen.

Nitrogen as ammonia is more readily available than the organic forms. In fact, organic nitrogen in its process of decay passes through the ammonia stage in becoming available; it is one of the first products that results from the decay of organic substances. The commercial nitrogen in this form is obtained almost entirely from sulfate of ammonia. It is readily converted into the nitrate form and quickly becomes available when placed in the soil. This form of nitrogen is especially used as a rainy-weather-available fertilizer for, until it changes into the nitrate form, it has the power of combining with certain minerals and organic substances

in the soil which prevent its loss by leaching. Commercial nitrate of ammonia contains about 20 per cent nitrogen.

In the form of nitrate, nitrogen is directly available to the plant as food. It is the most soluble form. Nitrate of soda, containing an average of about 15 per cent nitrogen, is the most common commercially. Neither nitrogen as ammonia nor as nitrate is so widely used for sweet potatoes as are the organic forms. There are instances, however, when the more available forms are used, either because of their cheaper cost or because of some specific purpose; as giving the plant a rapid start by the use of a quickly available form on very poor land.[1] Cotton-seed meal, which contains on an average from 6 to 7 per cent nitrogen, is by far the most commonly used form of nitrogen for sweet potatoes. When the cost of nitrogen a pound in this form is not greatly in excess of the cost in other forms, authorities are unanimous in recommending it. The long hot season during the growing period furnish conditions best suited to its rapid decay.

Phosphorus exists in the form of "organic" phosphates and as mineral phosphates. The latter are so termed in contradistinction to the organic forms because of their lack of organic or animal matter. As the organic phosphates are seldom used in sweet potato culture, discussion will be confined to the mineral forms.

The chief sources of mineral phosphates in this country are the raw phosphate rock of Florida and South Carolina, phosphates from the mines of Tennessee and Thomas slag which occurs as a by-product from the

[1] For more exhaustive study of forms of plant-food, see Farmers' Bull. 44.

manufacture of steel from phosphatic iron ores. None of these forms, however, is used in the raw state for sweet potatoes.

Superphosphates, of which acid phosphate is the most common commercial form, are obtained from the insoluble or very slowly soluble raw products just described. The process of manufacture consists in treating the finely pulverized raw products with sulfuric acid which renders soluble the phosphorus which they contain. In this process the phosphoric acid obtained is a definite chemical compound and its composition is the same irrespective of its raw state. Any material containing soluble phosphoric acid as its chief constituent may, therefore, be termed properly a superphosphate.

Acid phosphate, containing on an average 14 to 15 per cent of soluble phosphoric acid, is manufactured by treating 1000 pounds of raw phosphate rock with 1000 pounds of a dilute solution of sulfuric acid. The raw rock, containing about 30 per cent phosphorus which is very slowly soluble, is thereby converted into a compound having about one-half as much total phosphorus as did the raw rock but which is vastly more valuable as a fertilizer for ordinary crops because of the availability of the plant-food. This phosphate is the form used almost exclusively on sweet potatoes.

Potash exists chiefly in two forms, as chlorids or murates and as sulfates. Though the availability of the potash in these forms is about equal, the respective elements with which it is combined in the two forms exert considerable influence on its use for particular crops.

It has been found that the potash combined with chlorin is not so valuable for potatoes as the sulfate

form. It seems that a combination of chlorin exerts an undesirable influence on the quality of the crop. This behavior is perhaps more noticeable with Irish potatoes than with sweets. The supply of potash is obtained largely from the potash mines of northern Germany. Sulfate and murate of potash, kainit, sylvinit, high-grade sulfate of potash and double sulfate of potash are the most common forms. As with murate of potash, kainit also contains large amounts of chlorin, although in reality the potash is in the form of a sulfate.

For sweet potatoes, potash is best applied in the form of sulfate. It gives largest returns on light sandy soils and on lands with a high humus-content. Clay soils are usually well supplied with potash, With a good clay subsoil, when the surface is sandy, sweet potato crops do not respond noticeably to applications of potash, especially when the sand is not deep and plowing has brought some of the clay to the surface.

Potash is sometimes applied in the form of hard-wood ashes, which in the unleached state contains about 5 per cent potash. This, however, is usually an expensive medium and is seldom used except when the lime contained is decidedly unleached, when it contains in addition to 4 to 6 per cent potash, about 30 per cent lime and from 1 to 2 per cent phosphoric acid.

Commercial fertilizers.

Commercial fertilizers differ from farm and green-manures in that they exist in a form readily exchanged and handled in commerce. The following table[1] gives

[1] Farmers' Bull. 44.

the most common commercial fertilizers and their respective contents of manurial constituents:

TABLE XII.—COMPOSITION OF THE PRINCIPAL COMMERCIAL FERTILIZING MATERIALS.

Fertilizing material.	Nitrogen	Phosphoric acid.			Potash.	Chlorin.
		Available.	Insoluble.	Total.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Supplying nitrogen:						
Nitrate of soda	15.5–16.0	.....	.....	.....	.....	.....
Sulfate of ammonia	19.0–20.5	.....	.....	.....	.....	.....
Dried blood (high grade)	12.0–14.0	.....	.....	.....	.....	.....
Dried blood (low grade)	10.0–11.0	.....	.....	3.0– 5.0	.....	.....
Concentrated tankage	11.0–12.5	.....	.....	1.0– 2.0	.....	.....
Tankage (bone)	5.0– 6.0	.....	.....	11.0–14.0	.....	.....
Dried fish scrap	7.0– 9.0	.....	.....	6.0– 8.0	.....	.....
Cotton-seed meal	6.5– 7.5	.....	.....	1.5– 2.0	2– 3.0	.....
Castor pomace	5.0– 6.0	.....	.....	1.0– 1.5	1– 1.5	.....
Supplying phosphoric acid:						
South Carolina rock phosphate	.....	.....	26–28	26.0–28.0	.....	.....
South Carolina rock superphosphate (dissolved South Carolina rock phosphate)	.....	12–15	1– 3	13.0–16.0	.....	.....
Florida land rock phosphate	.....	.....	33–35	33.0–35.0	.....	.....
Florida pebble phosphate	.....	.....	26–32	26.0–32.0	.....	.....
Florida superphosphate (dissolved Florida phosphate)	.....	14–16	1– 4	16.0–20.0	.....	.....
Boneblack	.....	.....	32–36	32.0–36.0	.....	.....
Boneblack superphosphate (dissolved boneblack)	.....	15–17	1– 2	17.0–18.0	.....	.....
Ground bone	2.5– 4.5	5– 8	15–17	20.0–25.0	.....	.....
Steamed bone	1.5– 2.5	6– 9	16–20	22.0–29.0	.....	.....
Dissolved bone	2.0– 3.0	13–15	2– 3	15.0–17.0	.....	.....
Thomas slag [1]	.....	.....	.....	11.4–23.0	.....	.....
Supplying potash:						
Muriate of potash	.....	.....	.....	.....	48–52.0	45.0–48.0
Sulfate of potash (high grade)	.....	.....	.....	.....	48–52.0	.5– 1.5
Sulfate of potash and magnesia	.....	.....	.....	.....	26–30.0	1.5– 2.5
Kainit	.....	.....	.....	.....	12–12.5	30.0–32.0
Sylvinit	.....	.....	.....	.....	16–20.0	42.0–46.0
Cotton-hull ashes [2]	.....	.....	.....	7.0– 9.0	20–30.0	.....
Wood-ashes (unleached) [2]	.....	.....	.....	1.0– 2.0	2– 8.0	.....
Wood ashes (leached) [2]	.....	.....	.....	1.0– 1.5	1– 2.0	.....
Tobacco stems	2.0– 3.0	.....	...	3.0– 5.0	5– 8.0	.....

[1] In good Thomas slag at least 80 per cent of the phosphoric acid should be soluble in ammonium citrate, i. e., available.

[2] Cotton-hull ashes contain about 10 per cent of lime; unleached wood ashes, 30 to 35 per cent; and leached wood ashes, 35 to 40 per cent.

The percentage of available plant-food elements in a complete fertilizer is usually marked on the container. State laws require this of manufacturers and state inspection is usually very rigid. A 2-8-10 formula means 2 per cent nitrogen, 8 per cent phosphorus and 10 per cent potash. The nitrogen is often listed as ammonia, which in interpreting formulas is considered to be about $1\frac{1}{17}$ as valuable as nitrogen. Fertilizers should always be purchased on the basis of the available plant-food which they contain and not according to the price or brand of the fertilizer. The fertilizer lowest in price is often the most expensive medium through which plant-food may be purchased. In general, the actual plant-food contained in higher-grade fertilizers is least expensive.[1]

Home-mixing of fertilizers.

Thorough familiarity with fertilizing constituents, better facilities for handling and the ability to purchase in large quantities, makes legitimate the commercial manufacture of complete ready-mixed fertilizers. In spite of this, many sweet potato growers can save money by mixing their manures at home and if intelligent care is exercised as good results can be secured with the home-mixed goods as with that purchased ready-mixed. In many cases there may be an actual improvement in results as well as saving in cost, since the "carriers" are known and mixing can be done to suit specific conditions.

The approximate composition of the fertilizers desired must first be decided on and the form in which each constituent is to be applied must be determined

[1] Bull. 392, N. Y. Exp. Sta., 1914.

by the convenience and availability of the possible materials which will supply the desired plant-food.

For the northern commercial sections, Miller[1] recommends "a fertilizer analyzing 2 to 4 per cent of nitrogen, 8 per cent phosphoric acid and, when available, 8 to 10 per cent of potash." Assuming that cotton-seed meal is the most convenient source of organic nitrogen (which is preferred to inorganic forms for sweets), and acid phosphate and sulfate of potash the best carriers of phosphoric acid and potash respectively, the following fertilizer may be mixed:

Composition of fertilizers, 4 per cent nitrogen, 8 per cent phosphoric acid and 10 per cent potash:

(1) Use cotton-seed meal containing 6.5 per cent of nitrogen.	
(2) Use acid phosphate containing 16 per cent phosphoric acid.	
(3) Use sulfate of potash containing 46 per cent potash.	
(4) 20 Cwt. (in one ton) × 2 per cent N = 40 lb. nitrogen ÷ 6.5 (nitrogen) in c. s. meal = 615 lbs. c. s. meal	615 lbs.
(5) 20 Cwt. (in one ton) × 8 per cent phosphoric = 160 lbs. phosphorous ÷ 16 (phosphoric in acid phosphate) = 1000 lbs. acid phosphate	1000 lbs.
(6) 20 Cwt. (in one ton) × 10 per cent K. 20 = 200 lbs. potash ÷ 50 (potash in sulfate of potash) = 400 lbs. sulfate potash	400 lbs.
	2015 lbs.

By calculating the cost of such a fertilizer with local

[1] Farmers' Bull. 999.

prevailing prices of the ingredients and comparing this cost plus labor of mixing with the manufacturers' price for a ready-mixed product of the same analysis, the economy of home-mixing could be determined. Some soils would, perhaps, require no nitrogen at all, in which case the calculation for the other two elements would be made exactly as before and the deficiency in making a ton would be made up by the use of a filler. Often in buying ready-mixed fertilizers, the producer has to pay freight on a "filler" which is of comparatively no value as a fertilizer.

Mixtures adapted to the growing of sweet potatoes on most soils may be mixed in the following proportions:

1000 pounds of 16 per cent acid phosphate
600 pounds of cotton-seed meal
400 pounds of sulfate of potash.
Total, 2000 pounds.

200 pounds of sulfate of ammonia about 25 per cent pure
200 pounds of dried blood
1200 pounds of acid phosphate about 10 or 12 per cent pure
400 pounds of muriate or sulfate of potash about 50 per cent pure
Total, 2000 pounds.

This last mixture should analyze about 4 per cent nitrogen, 6 per cent phosphoric acid and 10 per cent potash. The nitrogen may be left out or reduced.

What fertilizer to apply.

It is impossible to give any specific fertilizer ration best to use on a crop of sweet potatoes. Even a chem-

ical analysis of a specific soil would be of little practical value in determining the "best" fertilizer. Every grower must make a study of his individual soil requirements by noting "results" rather than by theoretical calculations. For this reason it has been thought best to give as briefly as possible the fundamentals underlying fertilization and with this knowledge each grower can be guided in the intelligent manuring of specific fields.

In the commercial sections of northern production areas where the growing season is comparatively short, more liberal application of manures will be profitable than in the South. When rapidity of growth, earliness and high quality are important factors, even the most fertile soils contain too little quickly available plant-food for maximum yields. In such cases, more liberal and careful application of commercial manures must be resorted to.

Humus.

It has been said that "humus is just as necessary to make soil fertility as water is to make lime and sand into plaster." This is especially true of land on which the best yields of sweet potatoes are to be secured. Although the chemistry of humus is not thoroughly understood, it is known to be a very powerful factor in rendering soil loose and friable (when well-drained); it supplies plant-food in the form of nitrogen; it combines with many of the other fertilizing elements, making them available and effective; it is very important in controlling the moisture-content of the soil, in furnishing food for friendly bacteria, in enhancing the physical

condition generally and it has an important influence on soil temperatures.

Although a liberal supply of humus is very desirable on sweet potato land, it should be well decayed, the soil well-drained, and it should not be acid or sour. Humus becomes worthless with many croppings and its supply in the soil must be renewed from time to time. This is best done by the application of barnyard manure and the use of green cover-crops turned under. However, such applications of humus should be made to crops preceding the sweet potatoes in the rotation if it is to decay properly and be of most value.

Green-manures.

The question of providing in the rotation a leguminous crop to supply needed nitrogen and humus has been briefly discussed under rotation. Even when these crops are removed from the land, an actual gain in nitrogenous fertility results. The Rhode Island Experiment Station, in a five-year pot experiment, found that cowpeas and soybeans grown on land resulted in a gain in nitrogen. "The approximate five-year net gain of nitrogen in the presence of these two crops and the vetch which was grown alternately with each, was a ton of nitrogen per acre, about seven-tenths of which was contained in the twenty-five tons of moisture-free summer crops removed, and the remainder in the soil itself. These quantities should be considered with reference to the following facts, namely: the soil in the pots was 10 inches deep, somewhat deeper than the surface soil in many localities; the winter vetch was grown in a heated greenhouse; and furthermore, suf-

ficient water was given to supply all needs of the plants." [1] In many sections of the South, the growth of leguminous crops in the sweet potato rotation would be a most desirable means of supplying both nitrogen and humus, which are much needed on many of these soils. If the crops in rotation are corn, cotton, oats or wheat, leguminous crops should be sown with these, or after they are harvested, in which case they might also be used as a winter cover-crop. Velvet beans, peas or clover may be planted with the corn, or clover may follow oats or wheat. Very good results are secured by turning under a heavy crop of crimson clover early in the spring. Green-manuring, however, consists of more than growing a leguminous crop which is removed from the soil. It means the growing of a crop on the land which is plowed under. Many fields of so called "worn-out" land could be made to produce bountiful yields of high quality sweets by the use of one or two crops of legume turned under as manures.

Other materials as fertilizers.

Stable-manure, though supplying organic matter in its most desirable form and also adding nitrogen and smaller quantities of other food elements to the soil, should never be applied directly to a crop of sweet potatoes. When so applied it has a tendency to cause too rapid growth, resulting in large rough tubers of poor quality. When applied excessively, vine growth is over-stimulated at the expense of the tubers. Stable-manure is best applied to the crop immediately preceding the sweets and even then it should be well rotted. Well-rotted stable manure may be used at the rate of

[1] Bull. 147, R. I. Exp. Sta.

10 to 15 wagon-loads to the acre. It may be applied broadcast, and harrowed into the soil, or drilled into the rows before bedding.

Peat, muck and leaf-mold.— Clay soils and others having a tendency to compactness and those deficient in organic matter can often be improved for the growth of sweet potatoes by an application of peat, muck, or leaf-mold. Sometimes these substitutes contain as high as 4 per cent nitrogen. Their chief value, however, is in the humus which they contain. The distance which such substitutes have to be hauled will determine the advisability of use.

Poultry manure.—The value of poultry manure is too often unappreciated by farmers. This substance is rich in nitrogen and phosphoric acid. It is valuable as a fertilizer for sweets in the North where they are grown as a garden vegetable. If the full utility of this fertilizer is received, care must be taken of it, as a large part of the nitrogen may be lost by evaporation. Poultry manure, or any other barnyard manures should never be mixed with ashes since they contain alkalies which increase fermentation, causing a loss of nitrogen.

Hardwood ashes may be applied to sweet potato land at the rate of 1200 to 2000 pounds to the acre. A good grade of wood-ashes should analyze from 6 per cent to 8 per cent of available potash. They also contain considerable lime. The food value may be reduced by excessive leaching.

Lime is also applied to sweet potato land when a large amount of green material has been turned under for organic matter. This neutralizes the sourness that often is caused by the green crop. From one to two tons may be applied to the acre. Lime present in the

soil hastens the maturity of the crop and increases the yield. On poor soil, lime and potash work together to produce uniform sizes and shape. Lime, for the best results, should be applied the year previous to planting sweet potatoes.

Application of fertilizers. (Plate III.)

Since the sweet potato plant when transplanted in the field is ready to begin growth, all fertilizers are best applied sometime before the plants are set. The common practice is to apply commercial fertilizers in the drill at the time of making the rows. This is ordinarily done by distributing the fertilizer in the middles between rows, mixing it with the soil by stirring with a scooter or bull-tongue, and then bedding on top of it by throwing two furrows together with a turn plow. It is very important that kainit (when used as source of potash) be thoroughly mixed with the soil before planting, as cases have been reported in which this fertilizer injured the crop.

ROTATION

The growing of a series of crops on the same land in definite order throughout a period of years constitutes what is termed crop rotation.

Proper rotation is now recognized to be a necessity to maximum production and efficiency with all crops. In fact, it is quite as important to the permanent welfare of the soil as to the yield and quality of the plants grown, and the kind of rotation practiced will have fully as much influence on both as does cultivation or fertilization.

A seed-bed may be perfectly prepared; plant-food

may be present in abundance; the seasons may be ideal; and still a complete failure or a greatly reduced yield may be the reward because each year the field has had to nourish the same kind of crop, supplying it with the same amount of the same food elements and receiving in return the particular toxin or poison which is given off by the plant in question. Each plant takes from the soil its special kind of food and throws off certain root excretions, corresponding to perspiration in animals, which are poisonous to that particular plant but which perhaps would be unharmful to any other species. Each plant exerts a certain influence on the mechanical condition of the soil caused by the development of its peculiar root system which varies with different crops. Alternation of deep and shallow-rooted crops in the rotation require the use of other layers of soil. Each plant has certain insect enemies and is subject to certain fungous diseases which naturally become worse if the plant crop is grown in the same place year after year. Some crops are more exhaustive on the humus supply of soils than others, and rotation enables the maintenance of this humus.

Proper rotation facilitates diversification of crops which is essential to the proper distribution of farm labor.

Plant-food.

The demand on soil for plant-foods from year to year is varied by rotation. An "exhausted" soil is frequently depleted in some one food element due to growing continually some crop that uses more of that element than it does of other plant-foods. Such a soil is often exhausted only for the particular crop which

has been grown without alternation. A thousand pounds of sweet potatoes contain 2.9 pounds of nitrogen, .9 pounds of phosphoric acid and 5.1 pounds of potash, while a similar amount of Dent corn contains 16.2 pounds of nitrogen, 6.9 pounds of phosphoric acid and 4 pounds of potash.[1] Thus it is seen that sweet potatoes remove from the soil about two-thirds more potash than nitrogen, while corn removes more than four times as much nitrogen as potash. It would appear that a continuous cropping of corn would quickly exhaust the nitrogen supply, while successive crops year after year of sweet potatoes would tend to deplete the supply of potash more quickly than the other food elements. However, this consideration in favor of crop rotation is not considered of as much importance as formerly for the increased yields resulting will ordinarily take from the soil more actual plant-food than would be used by the smaller crops were rotation not practiced. The fact, however, that plant-food in the soil is continually being made available and that deficient crops use the elements in varying proportions may be of importance.

Root excretions.

The accumulation in the soil of certain root poisons or toxins may be avoided by rotation. Frequently when the soil has been well fertilized and diseases kept out, small yields of sweet potatoes are secured on a piece of ground after several years continuous cropping. Although little definite information is available on the subject, it is known that the roots of a plant throw off waste matters and that these excretions seem to be self-poisoning to the plant. Other plants, however, are not

[1] "Feeds and Feeding," Henry and Morrison.

noticeably injured by this poison and after a few years cropping in other varieties the toxid effect is destroyed by natural soil forces.

Mechanical effect on soil.

The prevailing opinion that "sweets" are hard on land is not without foundation. Not only are large amounts of nitrogen and potash removed but frequently the crop is not dug until late and the ground is often left bare all winter when the leaching rains rob the soil of its available plant-food.

Hogs are often left in the potato fields in wet weather when their rooting causes the soil to become hard and baked when it is dried out. The soil should never be molested when muddy either by animals or otherwise.

On heavy soils, the vines, especially when heavily manured, become very rank and when turned under cause too much acid in the soil. Under such conditions, an application of raw phosphate rock would be advisable. Sweet potato land should be amply supplied with organic matter but it should be well decayed and the soil should be loose and mellow.

Proper rotation of crops provides for sowing a winter cover-crop to prevent leaching; for the growth of legumes to be turned under and allowed to decay thoroughly; and for the alternation of deep and shallow-rooted crops which will preserve and improve the mechanical condition of the soil, making it easier and more economical to cultivate and allowing the production of a crop of the best quality.

Insect, fungous and weed enemies.

One of the most important advantages of crop rota-

tion with the sweet potato is the controlling of insect pests and fungous diseases which in sections seriously hamper the development of the industry. In speaking of control measures for the sweet potato weevil, which in Texas alone is exacting an annual toll of nearly 20 per cent of the crop, Chittenden [1] writes "Rotation of crops is a necessary measure in the eradication of this pest; indeed, injury may be prevented to a large extent by the selection of the field for planting." (See Chapter VII.) Miller [2] says, "A rotation in which sweet potatoes are grown on the land once in three or four years combined with seed selection and hot-bed sanitation, is effective in preventing loss from stem-rot, black-rot and other injurious diseases." The New Jersey Station recommends a rotation calling for sweet potatoes not oftener than once in four or five years for old sections and every three years for new ground if disease is to be controlled.

Some crops are favorable to the growth of accompanying weeds which are likely to become firmly established if the crop is continually grown on this same land. In the South, crops of the short-vined varieties of sweet potatoes may be almost completely choked out by Bermuda-grass which can easily be held in check by the use of a heavy cover-crop such as cowpeas. Johnson-grass, "nut-grass" and "Kerless" weeds are obnoxious enemies of the sweet potato. All can be controlled and sometimes completely eradicated by proper rotation.

Rotation to be used.

The crop rotation with sweet potatoes will necessarily have to be determined by the individual grower. It will

[1] F. H. Chittenden, Farmers' Bull. 1020, p. 18.
[2] Fred E. Miller, Farmers' Bull. 999, p. 5.

be governed by the prevailing soil and climatic conditions; by the kind of farming practiced; by the demand and market for particular crops that might be grown; by the inclination, taste or preference of the individual; by the land and equipment available; by the condition of his land and other circumstances which can only be decided by the individual.

The cut-over pine lands of the South are preëminently suited to the production of "sweets" and even the "worn-out" cotton and tobacco farms make good yields, when rotation includes leguminous crops for increasing the humus-content of the soil. Newly cleared land in this region produces heavy crops. As the clovers do not thrive on a large part of this land when planted so late (sweet potatoes in this section are harvested in November), such crops as oats and rye have to be depended on for winter cover. In Virginia and regions farther north, when potatoes are dug for the early markets, crimson clover may be sown for a cover-crop provided the potatoes are off by September 1 to 15 in New Jersey, Delaware and Maryland, and by September 30 in southern Virginia. Where the potatoes occupy the land too late for planting crimson clover, a cover-crop of rye or of oats and vetch should be used.

The following suggested three- and four-year rotations are taken from Farmers Bulletin 999 of the United States Department of Agriculture:

A. For the cotton-belt, where sweet potatoes are grown as a farm crop:

1. First Year. (a) Cotton, followed by rye for winter pasture or as a crop to turn under; or
   (b) Corn, with cowpeas or velvet beans planted as a soil-improving crops.

Second Year. Sweet potatoes followed by a winter cover-crop of rye or oats and vetch.

Third Year. Oats, followed by peanuts or cowpeas.

2. First Year. Sweet potatoes followed by a winter crop of rye or oats and vetch.

Second Year. Cotton, with rye sown between the rows for winter pasture or to turn under.

Third Year. Corn with cowpeas or velvet beans planted as a soil-improving crop.

AA. Four-year rotation for the southern sweet-potato section:

First Year. Sweet potatoes.

Second Year. Winter oats, followed by peanuts or cowpeas.

Third Year. Cotton, with bur clover between the rows.

Fourth Year. Corn, with cowpeas or velvet beans between the rows.

AAA. Three-year rotation for the eastern shore of Virginia and Maryland:

First Year. Sweet potatoes, followed by crimson clover or rye as a winter cover-crop.

Second Year. Early Irish potatoes. In many farms corn is planted between the rows of potatoes at the last cultivation; on other farms the potatoes are followed by fall vegetables.

Third Year. Winter oats, followed by cowpeas for hay.

These rotations are merely suggestive and will necessarily be changed according to the existing influences governing any case. Miller concludes, "In planning a sweet potato rotation, the importance of plowing under a soil-improving crop once every two or three years should be borne in mind. The crops to include in this rotation will vary according to local conditions. Wherever practicable a leguminous crop, such as cowpeas, soybeans, velvet beans, or crimson clover should be used in order to supply nitrogen as well as humus."

CONCLUSION

In growing sweet potatoes, quality, which is measured by size, shape and cooking, is a very important consideration. These characteristics are largely influenced by the soil, the rotation followed, and the fertilizer applied. An abundance of phosphoric acid and potash with smaller amounts of not too quickly available nitrogen are essential. A yield of 200 bushels of sweet potatoes, not including vines, removes from the soil approximately 30 pounds of nitrogen, 10 pounds of phosphoric acid and 30 pounds of potash. Fertilizers containing a liberal supply of potash in comparison to the other elements seem to give best returns under average conditions, though clay soils do not respond so readily to this element. In general, the best growers have found a small amount of nitrogen and a larger percentage of phosphorus and potash to give most profitable returns. A quantity of each element somewhat in excess of the actual amount removed from the soil by the plant should be applied, as some will be lost by leaching. Twenty pounds of pure nitrogen to the acre is the maximum that should be used if high quality is not to be sacrificed to excessive yields. The New Jersey Station has found that commercial fertilizers alone can be depended on to furnish plant-food, but barnyard and green-manures are valuable for supplying organic matter or humus. Organic nitrogen is preferred to the more soluble forms. Commercial fertilizer is best applied in the drill before putting out the plants, while stable and green-manures should be applied to crops preceding the sweet potatoes in the rotation. Organic matter in the soil should be well decayed.

CHAPTER VI

VARIETIES

THE question of varieties is largely a local problem depending on special conditions and on the requirements of the market served. Considerable confusion exists both in this country and in the insular possessions with reference to varietal characteristics. This is due in a large part to the fact that the sweet potato is subject to sudden mutation or the appearance of sports giving rise to many new varieties, which may or may not continue in existence. Often even the name for well-known varieties is extremely local, varying for the same variety in different sections. Many growers have undertaken the improvement of some standard variety and after a few years' selection have given it an entirely new name. These influences combined have given rise to a vast number of varieties, many times differing from some other only in the local adoption of a particular name. For instance, the Pumpkin yam, the Georgia Split-Leaf and the East Texas yam are identical but are sold from the different sections under the various names. In Porto Rico a great many varieties are found but only the Mamey varieties, namely the Mameyona or large Mamey and the Mameyita or small Mamey, and also the Blanca or white, are known by the same name all over the island.

Several tentative classifications for varieties have

been suggested by various writers but no key has yet been made sufficiently complete to rely on in accurate classification.[1] Roughly speaking, the distinguishing characterization of various varieties are included in: (1) the length of vine, which may be either long or bunch; (2) the shape of leaves, which are either deep cut, shouldered or entire; (3) the texture of the meat, which is either sirupy, mealy or intermediate; (4) the color of the flesh, which may be yellow, white or mottled white and yellow; and (5) the color of the skin, which is white, yellowish, light red or purple. Many minor characters may be noted, such as prominence of leaf-veins, color of leaf-veins, and tint of leaves. In order to make a treatise on varieties as practical as possible, it has been thought best to give all of the available information on the better known kinds, even though some of these varieties are only known locally by the name given.

The descriptions given below are in somewhat the form of notes as made by the authors from observation, elaborated in cases by descriptions from other authorities. All available descriptions of varieties except a very few well known ones are admittedly incomplete and the notes on characteristics and importance constitute only such information as is known to be reliable and accurate. A longer study and more systematic effort on the part of investigators is sure to give some very valuable data on varietal characteristics in the future, and if the descriptions given here seem incomplete it is

[1] A letter from Jno. H. Beattie of the Bureau of Plant Industry, Washington, D. C., to the author, dated July 30, 1919, says, "During the present season we are planning to test our variety key out, and if it shows the same results as it did last year, we will publish the material."

hoped the reader will remember that only time and study can bring about a standardized varietal characterization with any plant so subject to change by climate, mutation and selection as is the sweet potato.

ANGUILLA.— This variety seems to have almost disappeared from the market. It was formerly well known on the eastern coast where it grew to great size. In this respect it was similar to the Peabody, but differed in its white skin and white flesh. This variety is characterized by the immense size the potatoes attain, the heavy crop and the poor quality as judged by the general southern taste. It is rapidly going out of cultivation except as hog-feed.

ARKANSAS BEAUTY.— This is a long tapering potato, very smooth and yellowish in color. The roots, which are very uniform in size, are borne in clusters. The skin is pronounced yellow, while the flesh is light yellow and very delicate looking. The vine growth is good but it is a poor yielder.

BIG STEM JERSEY.— This potato is distinguished by being the most widely cultivated of all varieties for the northern markets. Growers on the eastern shore have long grown this and its near relative, the Little Stem Jersey. The Virginia Truck Experiment Station at Norfolk has given the following official description of the variety: "Vines long, heavy, leaves large; potatoes long, spindle shaped, irregular, often veiny, many very large. Skin bright yellow, flesh creamy to pinkish. Table quality fair, dry. A fairly heavy yielder, especially for early crop. Not adapted to hamper pack. There are pink-fleshed strains especially good for canning, since the flesh of the potato is of a very attractive color for this purpose. The table qual-

ity of these strains is also superior." [1] In addition to the above description, it might be added that the vines are long, slender and creeping. The leaves are small, green on both sides and entire. The potatoes are late in season to mature. This variety is a heavy yielder and can be grown farther North with better success than the moist-fleshed varieties. (See Plate IV.)

BLACK SPANISH.— This variety is identical with the Nigger Killer, or Negro Choker, described below.

BRAZILIAN.— The roots of the Brazilian are large, smooth, roundish and uniform in shape. The skin is light yellow; the flesh white. It is a hardy variety and very prolific, with a luxriant vine growth.

CREOLA.— This is a heavy yielding variety, very valuable for stock-food. The foliage is characterized as follows: "Stem single, rather thin, white below surface, deep ruby red above surface of ground. Leaf somewhat inclined to be triangular. Margins entire. Medium green above and grayish green underneath. Vines light green, rather large. Petioles medium thick, very long, light green color." [2]

DOOLEY YAM.— One of the best yielders and keepers among the long list of strictly southern grown sweets is the Dooley. This is an old variety and is well known and extensively produced in all of the southern states. The vines are slender but very long, often attaining a length of 15 feet or more. They are dark green and the leaves are entire with three to five tiny marginal points according to the age of the leaf. The dark green vines blend into a greenish-purple color as the

[1] T. C. Johnson and J. T. Rosa, Jr., Bull. 19, p. 414, Va. Truck Exp. Sta.

[2] T. C. Johnson, Va. Truck Exp. Sta., information to author.

roots come to maturity. The potatoes are fair in size, being short, smooth and spindle-shaped. The flesh is dark yellow to salmon in color, very soft, sweet and juicy when baked. The Dooley is not an early maturer. (See Plate IV.)

DELAWARE.— This is one of the dry mealy types originating from the original Nansemond, or Jersey Sweet, of Maryland and Virginia.

FULLERTON YELLOW YAM.— The potatoes are very long in proportion to their diameter. They are borne in clusters and are very prolific. The skin is light yellow; the flesh white spotted with yellow, and sweet and sugary in nature.

FLORIDA YAM.— In a series of variety tests conducted by C. E. Brehm, of the Tennessee Station, the Florida yam grown under identical conditions with a number of other kinds, was only equalled in yield by the Nancy Hall. Brehm says: "Although seedmen differentiate between the varieties Florida yam and Nancy Hall, I am confident that there is no difference. The only difference that I can see is that when shipments are made North they call sweet potatoes of this variety Nancy Hall and when shipped South they call them Florida yams. From the standpoint of appearance and yield they are identical."

GENERAL GRANT.— This variety has been noticed to produce very few small potatoes. The roots are either of good size or they are strings. The large potatoes are smooth and well-shaped. The strings are worthless. The skin is very light yellow and the flesh pure white. The vine growth is prolific but the yield of potatoes is small.

GOLD SKIN.— This variety belongs to the Nansemond

class together with the Yellow and Red Nansemond, the Delaware, Big and Small Stem Jersey and the Red Nose. The name "Gold Skin" seems to be more of a trade name for "Jersey Sweets" rather than a term designating a distinct variety with outstanding varietal characteristics. Gold Skins are sold extensively on the northern markets. They have the mealy flesh characteristic of the Nansemond potatoes.

GEORGIA OR SPLIT-LEAF YAM.— This variety is extensively grown for home use throughout the South Atlantic and Gulf states and is known under several local names, such as the Georgia Buck, Split-Leaf and East Texas Yam. The vines grow long and slender; the stems are light green in color; the leaves are the same color and seven-parted, being very deeply cut. Johnson [1] describes the vine growth as follows: "Stem branching, bushy, rather slender, portion below surface of ground is white to pinkish, and that above surface is pinkish to green. Leaf is deeply divided, prominent shoulders; margin entire; color medium green upper surface, grayish green lower surface; veins heavy, light green; petioles thick, moderate length, light brownish color." This variety is a good yielder and is adapted to growing for home use and for markets demanding a sweet, very moist potato.

HAYMAN OR SOUTHERN QUEEN.— The Hayman and Southern Queen are identical, having whitish skin and creamy flesh. This variety and the Nancy Hall are the only "yam" kinds grown in the eastern shore production section. The Hayman has long been well known in that section but years ago it was taken up by B. K. Bliss, then a leading seedman in New York City, and

[1] T. C. Johnson, Va. Truck Exp. Sta., information to author.

sent out as a new potato under the name of Southern Queen. It is now known in many sections by the latter name. It is very early, unusually productive and is considered one of the earliest varieties to keep in storage. It is much improved in eating quality by storage and though not a very choice eating potato in fall and early winter, it becomes very good indeed in late winter and spring. It is of a very light color outside, presenting a grayish-white rather than yellow appearance. The flesh is pale yellow. The vine growth is heavy. The tubers are inclined to become over-large in rich soil, unless early digging is practiced. (Plate IV.)

Jewel Yam.— This is a yellow potato very like the dry Nansemond but with the sweet soft flesh of the yams. It was formerly grown to a limited extent through the Carolinas. It is a heavy yielder with prominent veins and is almost identical in appearance and quality with the Yellow Barbadoes.

Key West Yam.— This is one of the sweet juicy potatoes similar to the Porto Rico. It is a good yielder and sells well on the southwestern markets. It is largely grown in the Manhattan sweet potato section of Kansas and perhaps equally extensively in other parts of the Southwest. It is also well known on the eastern coast. Because of the heavy yield, it is largely used as stock food. "Stems branching and bushy, quite thick; color below ground pink, above ground deep ruby red; leaf auriculate, sharply pointed, mostly shouldered; margins very finely serrated; dark green upper surface, light green under surface; veins prominent, purplish color; petioles long, thick, with green purplish tinge." [1]

[1] T. C. Johnson, Va. Truck Exp. Sta., information to author.

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PLATE V.— Diseases of sweet potatoes. *a*, A section through a sweet potato showing the blackened ring just below the surface caused by the stem-rot fungus. *b*, A sweet potato plant showing the characteristic symptoms of stem-rot. *c*, Sweet potato black-rot. Small sweet potato plant showing the characteristic blackening of the underground part of the stem. *d*, Soft-rot. A sweet potato showing the moldy growth of the fungus causing soft-rot. *e*, Scil-splotch.

LITTLE STEM JERSEY.— The Little and Big Stem Jerseys are extensively grown for the northern markets by all farmers in the eastern shore sweet potato district, where the Eastern Shore of Virginia Produce Exchange has done much to standardize the production. Bulletin 19 of the Virginia Truck Experiment Station gives the following description of the variety: "Vines long, slender, leaves small; potatoes uniformly medium sized, regular, rounded to spindle shaped; bright yellow skin, creamy flesh, a moderate yielder; table quality good, dry. This variety is especially adapted for shipping in the hamper pack to northern markets." The vine growth is similar to that of the Big Stem Jersey except that it is more slender. The potatoes are smaller, more uniform, smoother and less veiny than the Big Stem Jersey, according to Miller.[1]

FIGURE 12.— A hill of healthy Little Stem Jerseys having more than five potatoes of marketable size. Fifty hills of such potatoes will give a barrel of marketable potatoes and some culls. Such healthy high-yielding hills of uniform potatoes are especially good for seed.

FIGURE 13.— A hill of healthy Little Stem Jerseys with potatoes of good shape, but not large enough to market as primes. This photograph is the same magnification as Fig. 12.

[1] Fred E. Miller, Farmers' Bull. 999, p. 28.

Plate IV shows two types of Little Stem Jerseys (listed Yellow Jerseys) generally grown. One represents the long spindle type, and the other a short chunky strain. (See Figs. 12 and 13.)

MEYERS EARLY.— This is a sweet, rich, yellow-fleshed sort resembling in character and quality the Nancy Hall. It is a selected strain of the Nancy Hall and is almost identical with it. It is known throughout Georgia, but is not widely distributed in other states. The vines have short nodes rather close together, and with medium to small "entire" leaves. The Meyers Early is said to grow a little longer than the Nancy Hall and the veins on the roots are more pronounced. In fact, the description of a well-grown Nancy Hall potato will fit the Meyers Early very well.

NANCY HALL.— This is the most popular of all the yellow "yam" varieties. When cooked, the flesh resembles closely that of the Pumpkin yam of Georgia and the Norton yam of North Carolina. It does not resemble these before cooking, however. This variety naturally grows short and chunky and the skin is pale yellow with stray streaks of pale pink. The flesh is deep pumpkin yellow when cooked. The Nancy Hall, under field conditions, is outstanding in producing a greater amount of No. 1 bakers with fewer jumbos and culls. The potatoes are of good shape, rather prolific and are very early maturers. The vine growth is luxuriant. The vines are medium long (3 to 5 feet) and green except for a purple stain at the junction of the blade and petioles. The leaves are entire. (See Plate IV.)

NANSEMOND OR JERSEY SWEET.— The original Nan-

semond, or the old yellow sweet potato of Maryland and Virginia, is a dry yellow potato popular in the northern markets. This potato, renamed in New Jersey, has given rise to the Delaware and the Red Nose varieties and to the various other strains of the Jersey potatoes.

NIGGER KILLER.— The Nigger Killer, or Nigger Choker, has a purplish red skin and the whitest flesh of any potato. It is very dry but really sweeter than the dry yellow varieties. The vines are very long, vigorous and dark purple in color. The potatoes are long, cylindrical and crooked. The quality is poor, the variety being grown mostly for stock-food.

NORTON YAM.— This variety belongs to the pumpkin colored yams, and is largely grown and sold throughout North Carolina. It has a yellow skin and the flesh is dark pumpkin colored when cooked.

OLD FASHIONED YELLOW YAM.— "Stem is medium thick, white below soil surface and purplish above. Leaf is very deeply divided, with three lobes and two shoulders; margin entire, light green above and gray green under surface; veins moderately heavy, light green in color; petioles are thin, rather short, light purplish in color." [1]

PEABODY.— This potato grows to an immense size, has yellow flesh, red skin, and is very dry and tasteless. It is often sold on the Raleigh, North Carolina, market, when about one-fourth grown, as there are usually no good potatoes on the market at that time. When fully grown, it will not sell for table use in the South but is frequently used as food for hogs, the animals being turned on the fields to gather the roots as desired.

[1] T. C. Johnson, Va. Truck Exp. Sta.

PIERSON.— This kind resembles quite closely the Red Bermuda described below. The roots are light yellow, well shaped, but often very much crooked and rough, with light yellow flesh. The Pierson comes early and finds some sale on the extra early markets. It is not a heavy yielder. Johnson describes the vine growth as follows: "Stem single, long, branching rather thick, white below surface, bright reddish to purplish above surface of ground. Leaf auriculate, very sharply pointed; margins entire; upper surface of leaf is dull green with purplish pink near edge; lower surface gray green; veins prominent, medium size; petioles slender, rather long, light green, with purplish tints."

POLO.— This is medium to large in size, very smooth, the roots rather round and the skin and flesh white. The vine growth is luxuriant.

PORTO RICO.— Growers throughout southern Georgia, Alabama and Mississippi and in northeast Texas have in recent years become enthusiastic over the possibilities of the Porto Rico potato. It is said always to give a good yield on almost any soil, although some growers claim it does not thrive on new ground. It not only yields well but is a fair keeper, ships well and is good as soon as dug. This variety, though not as widely known as the Nancy Hall and the Nansemond, is very rapidly becoming popular on the big markets. The Porto Rico, however, seems to be very susceptible to attacks from the sweet potato root-borer or sweet potato weevil. The potatoes are medium large, rounded, regular, deep salmon skin, very rich salmon flesh, sweet and juicy and in the South are considered very choice for baking. (See Plate IV.)

PRIDE OF KANSAS.— This variety is grown to a limited extent in certain parts of Kansas where it originated. It is not a standard variety and is not known and demanded on the markets outside of the purely local trade in the sections where it is grown.

PUMPKIN YAM.— This is a yellow or pumpkin-colored sort similar in color of roots to the Nancy Hall. The vines are long and the leaves entire. The stems are green and hairy and the leaves are green on both sides. The roots are medium sized, smooth and well formed with prominent bright-yellow veins. The flesh is mottled yellow and white with yellow predominating. The potatoes are formed unusually deep in the ground and for this reason are not so readily attacked by the sweet potato weevil, though the roots seem quite susceptible to fungous diseases. This variety is very sweet, very moist and soft in texture. (See Plate IV.)

PURPLE YAM.— This potato grows very long in proportion to its diameter. The skin is purple; the flesh white. It is a very poor yielder. The roots are borne near the surface of the ground, making the soil crack open more than is customary with heavier yielding varieties. The vines are large in size but the stems are spaced far apart with few leaves.

RED BERMUDA.— This is especially adapted for use as stock-food. It is a very heavy yielder, the vine growth is vigorous and the potatoes seem unusually hardy and free from disease. This variety belongs to the "yam" group but it not so sweet and juicy as the Porto Rico. The roots are rose red and the flesh light yellow. This potato will thrive farther north than most of the so-called yams.

Red Brazil.— "Stems single, thin, light pink below surface of ground, deep ruby red above surface. Leaves long and sharply pointed; margins finely serrated; leaves are light green to purplish above and grayish green on under surface; veins are prominent, purplish in color; petioles thin, medium length, with purplish color." [1]

Red Carolina.— The variety is nothing more than the Red Jersey sold under a name indicating its place of production.

Red Jersey or Red Nansemond.— This variety was a bud sport from the Yellow Nansemond. The vines are identical in appearance and the taste of the flesh is quite similar. This variety is popular on markets which show preference for a red-skinned potato. It is a heavy yielder and finds more sales on home markets than in shipping. (See Plate IV.)

Red Nose.— Among the offsprings of the old original Nansemond, or Jersey Sweet, is the Red Nose. This is a yellow-fleshed yellow-skinned sort with brownish-red blotches around the neck.

Shanghai.— The vine growth is very luxuriant, the stems growing large and vigorously. The roots resemble those of the Nigger Killer in shape, growing very long and cylindrical, but in color they are almost white. The meat is yellowish-white but turns a rich creamy yellow on cooking. It looks better than it tastes, as the flavor is rather poor and it is somewhat dry and mealy. It is a good yielder and is used to a limited extent in the Gulf coastal regions of Alabama, Mississippi, Georgia and Florida for stock-food.

[1] T. C. Johnson, Va. Truck Exp. Sta.

SHANGHOR YAM.— Keitt describes this potato as being "A somewhat irregularly shaped, white fleshed variety, skin slightly yellow. Much larger percentage of large to small tubers than that of White Spanish. Seems entirely free from disease. The potato is not what is usually called a yam, for it analyzed high in starch and low in sugar. It is not prolific." [1]

TENNESSEE NOTCHLEAF.— This potato is described by Keitt as: "Rather small, somewhat stringy potatoes, which are borne in large clusters. It is a yellow fleshed variety. Was attacked by a white rot before gathering. Very prolific, but makes very little growth of vines."

TOLMAN VARIETY OF OLD SPANISH.— The Spanish potatoes constitute a distinct class characterized by the slim narrow crooked potatoes with white skin inclined to pinkish shades and with grayish-white flesh. The Tolman strain is very similar to its close relative, the White Barbadoes.

TRIUMPH.— The Triumph is the earliest potato on the market and being white and mealy sells well in the North. It is not so good for the southern trade and does not sell so well after the early season demand is over. The Triumph is not a good keeper. It is a heavy yielder and is noted for the prominence of the veins and the large size of the roots when left in the ground until mature. The vines are bushy in nature and the leaves deeply cut. Because of the bushy nature of the vines, they are very easy to cultivate. The vine growth has been described as follows: "Leaf auriculate, pointed, double shoulders; margin irregular

[1] T. E. Keitt, S. C. Exp. Sta., Bull. 146, 1908.

and serrated; color, upper surface deep green; lower surface, light green; veins, heavy, deep red; size, medium to rather small; petioles, thick, long, green and purplish." [1] (See Plate IV.)

Vineless Bunch Yams.— The Vineless seems to be a sport from the Norton Yam, as bunch sorts frequently appear among the Nortons. The roots in appearance and quality are identical with the Nortons. This variety is described as follows: [2] — "Long, tapering, uniform; but rather small tubers; having a yellow skin, and white and light yellow mottled with white flesh, with some deeper yellow spots. Not much vine growth and a shy bearer." (See Plate IV.)

White Barbadoes.— This is another of the Spanish potatoes and is almost identical, if not quite so, with the Tolman variety of Old Spanish. Both the white and yellow Barbadoes are thicker in shape than the Old Spanish. The White Barbadoes is pale whitish in flesh, and yellow outside.

White Spanish.— This is described by Keitt as follows: "Very irregularly shaped, a few being large, smooth and roundish; but the majority being long and stringy. They have a perfectly white flesh and white skin. They are not prolific, but make a heavy growth of vines." [3]

White Yam or White Belmont.— This variety is very hardy, is a big yielder, is unusually sweet for a white potato, and is largely used for stock-food. The vine growth has been described as follows: "Stem branching, rather bushy and very thick; light green

[1] T. C. Johnson, Va. Truck Exp. Sta.
[2] S. C. Exp. Sta., Bull. 146.
[3] T. E. Keitt, S. C. Exp. Sta., Bull. 146, p. 6.

below surface and dull deep red above surface of ground. Leaves heart shaped, pointed; margins entire; deep green upper surface, gray green lower surface; veins prominent, green color, medium size; petioles short, dull green." [1]

YELLOW BARBADOES.— This potato has sweet soft flesh very much like the Jewel yam. The roots are noticeable by their very prominent veins. The roots are yellow inside and out, differing in this respect from the White Barbadoes which, although possessing a yellow skin, has whitish flesh.

YELLOW BELMONT.— This potato, which has been illustrated in various publications as a distinct variety, seems very closely allied if not identical with the Yellow Nansemond or Yellow Jersey. It is yellow inside and out and has a rather dry mealy texture. The tubers resemble the Small Stem Jersey more closely than the Big Stem, being smooth and less veiny than the latter. For all practical purposes, the Yellow Belmont may be considered a short chunky strain of the Yellow Jersey. (See Plate IV.)

YELLOW NANSEMOND.— The Nansemond class has many subdivisions, among which is the Yellow Nansemond. It is a long, smooth, tapering uniform yellow potato with almost white flesh. The roots, which are small, are borne in clusters prolifically. The vines and leaves are small.

YELLOW STRASBURG.— This is a heavy-yielding variety used largely for stock-food. It is not widely grown and is not known on the markets.

[1] T. C. Johnson, Va. Truck Exp. Sta.

Of all the varieties of sweet potatoes given above (and there are perhaps a hundred more subspecies), only about a dozen are important from the market standpoint. The Jersey type is generally preferred on the northern markets, though some of the moist fleshed kinds, especially the Nancy Hall, are being rapidly introduced into markets where heretofore a prejudice existed against southern potatoes.

The southern markets demand the moist fleshed variety or the so-called yam kinds. The Nancy Hall and the Porto Rico are the most popular and widely grown for the middle and late markets, while the Triumph (a medium dry variety) is most popular for the extra early market.

When grown for stock-food only, the heaviest yielding varieties such as the Yellow Strasburg, Red Bermuda, White Belmont and Hayman, should be used. The contention of some growers that the high sugar-content of some of the lesser yielding kinds will offset the advantage of big yields in fattening stock has not been found to hold true in practice.

CHAPTER VII

INSECTS AFFECTING SWEET POTATOES

It is commonly thought that the sweet potato is not affected seriously by insect pests. The home garden or small patch many seasons is practically free from insect injury, but the commercial grower will have to fight several insect enemies, some of which do millions of dollars' worth of damage annually to the sweet potato crop. The different sections of the country have their specific insect enemies, the southern states possessing by far the greater number and suffering much more material damage than the eastern and middle western states.

Insects that affect the sweet potato plant are divided into two general classes, the biting or chewing insects, and the sucking insects. The first class destroy parts of the plant or the tubers by gnawing or eating, and leave visible signs. The sucking insects obtain their substance by sticking a small thread-like bill into the plant and drawing the juices out without leaving visible signs to the natural eye. The first class, or biting insects, usually do much more damage than the sucking insects.

THE SWEET POTATO FLEA-BEETLE

(*Chætocnema confinis*)

As soon as the sweet potato plants are set in the field, they are often attacked by millions of small brownish-

black flea-beetles. The leaves are affected by having channels eaten out in both surfaces, the work being characteristic of this particular species and quite different from other flea-beetle injury. As a result of these attacks, many of the leaves of the newly set plants are killed outright; some turn brown and partially decay. New leaves usually put out from the stalk and thus prevent the plant from dying, but this injury checks the growth of the plants to a considerable extent, and in some cases kills them. Some seasons this injury is more serious than others, and some authorities claim that it is worse on low land. It is most serious on lands that were planted the previous year to potatoes, and the first injury is usually near hedge-rows, old fences, or other rubbish, where the beetles have hibernated during the winter. This beetle is about 1/16 inch long, thick-set, of a brownish color, and the wing-covers when seen under the microscope are distinctly furrowed.

The beetles hibernate over winter in rubbish under logs, leaves, or other vegetation, and emerge in the spring, usually about May. They mate as soon as they have fed, and after doing damage to the young plants that are set in the fields they usually disappear about the middle of June. Very little is known about the early stages of the insect, and they have never been found on sweet potato plants. The larva most probably feeds on the refuse of bindweed and morning-glories; it is a slender white grub about 1/8 inch long. The beetles appear in August, but do not as a rule feed on the tough sweet potato plants at this season.

Many of the beetles will be killed, if, when the plants are taken from the draw-bed, they are dipped in a solution of arsenate of lead 1 pound to 10 gallons of water.

By combining this solution with bordeaux mixture at the rate of 4–4–50, it will also serve as a repellant and probably will be more effective than the plain arsenical dip. All plants should be allowed to dry partially before setting out. Dipping the plants is preferable to spraying as it saves much time and they can be more thoroughly and evenly covered by this method, and it is also less expensive. Late planted sweet potatoes are less seriously injured than early set ones. Sturdy plants will withstand the attack and recover from the injury much better than weak plants.

TORTOISE BEETLES

One of the commonest pests of sweet potatoes is the tortoise beetle. There are several species belonging to the Chrysomelidæ, which are commonly known as gold-bugs or leaf-eaters. They attack the leaves of the plants in both the larval and adult stages.

The tortoise beetles hibernate over winter in rubbish and trash of any kind that affords them protection from the cold. In the early spring they feed on the morning-glory, which is probably their original host-plant. As soon as the plants are set in the field, the beetles begin to eat large round holes in the leaves and so completely riddle them that many plants have to be re-set. Rarely are new shoots seriously eaten or the eggs deposited on them. The larvæ hatch during the first half of June in Maryland; probably earlier in the South, and somewhat later in the northern and north-central states. The larvæ are very ugly and each is provided with a tail-like fork about as long as the body. Upon this fork is heaped the excrement and cast skins of the larva, and they are often overlooked or taken

for a bit of mud sticking to a leaf. This bulk borne on the fork has given them the name of peddlers. When fully grown, the larva fastens itself to a leaf, its skin splits along the back, and the pupa is held to the leaf by its fork. About a week or ten days later, the adult beetle emerges, eats for a time and then disappears from the sweet potato patch until the following spring. It doubtless feeds on its wild food plants until cooler weather drives it into hibernation.

The two-striped sweet potato beetle (*Cassida bivittata*).

This species is usually the most common of the tortoise beetles attacking sweet potatoes. The beetle is pale or yellow-brown, striped with black. The larva is yellowish-white with a longtitudinal band along the back, on either side of which is a much lighter band.

The black-legged tortoise beetle (*Cassida nigripes*).

This species very closely resembles the golden tortoise beetle, but is not so brilliant in color, is larger, has black legs and three black stripes on each wing-cover, and is larger and more readily seen than the golden species. The larva is a bright straw-yellow with two black marks just back of the head, and with the body-spines tipped with black. As with the adult, the larva is much larger than that of the golden beetle. This larva causes more injury to the plants, although possibly it is not as common as the striped beetle. The eggs of the other species are laid singly, while those of the black-legged tortoise beetle are more or less bunched, usually placed in rows of about three dozen. As soon as the larvæ hatch, all being on one plant or leaf, their

injury is very noticeable, certain plants being devoured and others not injured at all.

The golden tortoise beetle (*Coptocycla bicolor*) (Fig. 14).

This is one of the commonest species and is found on morning-glory and bindweed during practically the whole summer. The beetles on first emerging are dull orange with three prominent black dots on each wing-

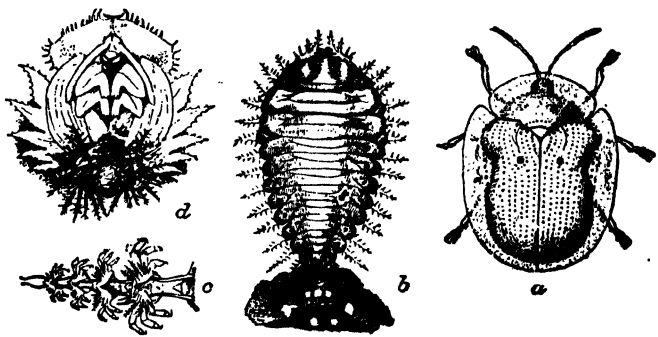

FIGURE 14.— The golden tortoise beetle: *a*, adult; *b*, larva; *c*, faecifork; *d*, pupa (enlarged).

cover, but a little later they assume a metallic color, shining like the most brilliant colored tinsel, and the black spots are not so conspicuous. All the tortoise beetles, and particularly this species, have the habit of dropping quickly to the ground and feigning death when the plant is shaken or when they are disturbed.

The eggs of this beetle differ from those of other species in having three spinal prongs projecting from the posterior margin. The larva is easily distinguished

by being nearly concealed under the heavy load of excrement which it supports on its spine. Usually it is of a dark brown color, being browner around the edges and a lighter shade along the middle. The pupa resembles the larva.

The mottled tortoise beetle (*Coptocycla signifera*).

This beetle is strikingly different from the other species in being black marked with golden spots and usually with a band of black extending across the shoulders to the edge of the transparent margin of the wing-covers. The larva is a pale smooth yellow during its early stages, but after the last molt the color changes to green, and after the excrement is removed from the fork it is very difficult to recognize on a green leaf. The larva does not feed during this last stage. The pupa is also green, but probably brighter than the larva, and marked by a few black bands around the first abdominal spiracles.

The argus tortoise beetle (*Chelymorpha argus*).

This is the largest of the tortoise beetles, although it is not as common as the preceding species. It is also injurious to several other plants, among these being raspberry, horse-radish and milkweed. The adults are usually brick-red in color with six black dots on the prothorax and six on each wing-cover which is variable in size and color. The extension of the wing-covers present in the other tortoise beetles is lacking in this species. The eggs are laid in a bunch supported by a long stalk. When the larva hatch, they remain close together and very quickly defoliate the plant. When

full grown the larvæ average about ½ inch. They are slightly convex, of a pale yellowish color, marked with numerous dark brown tubercles and prominent lateral spines. The pupa is of a yellowish color, marked with dark brown which in time becomes almost black.

Control of tortoise beetles.

From the similarity of life history and habits of these closely related species, their control may be the same. The adult beetles do the bulk of the injury just after the plants are set. It is advised that they be dipped in arsenate of lead before setting, as for the flea-beetle. If the beetles become serious in the field, plants should be sprayed with arsenate of lead, 4 pounds to 50 gallons of water. All places of hibernation, such as fence-rows, hedge-rows, woodlands and trash, should be destroyed during the winter, as this will kill many of the adults in hibernation.

SAW-FLIES. (Fig 15)

Probably the first injury from saw-flies was reported from Ocean Springs, Mississippi, in 1886, by C. V. Riley,[1] the larvæ practically ruining an entire crop of sweet potatoes. This pest is very injurious in certain seasons, the most damage probably being in the southern states. Saw-flies have since been found on sweet potatoes and morning-glories in Nebraska, Iowa, Illinois, and several other central and eastern states. The injury from these flies cannot be said to be serious, and the outbreaks are more or less sporadic and local. The writer, in 1919, found about a 50 per cent defoliage

[1] C. V. Riley, formerly of Bureau of Entomology.

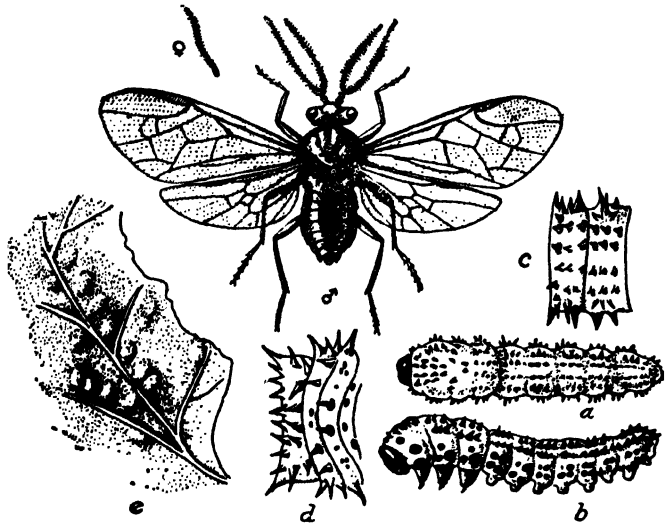

FIGURE 15.— The smaller sweet potato saw-fly (*Schizocerus ebenus*): *a*, *b*, larva; *c*, *d*, segments of larva showing spines; *e*, eggs deposited under leaf; *f*, male saw-fly; *g*, antenna of female saw-fly. All much enlarged; *c*, *d*, greatly enlarged.

near Ocean Springs, Mississippi. Two species have been identified on sweet potatoes, *Schizocerus ebenus* and *Schizocerus privatus*. These insects usually commit their depredations in the middle of the summer, probably the first appearance being in July. The eggs are deposited on the leaves and the larvæ hatching from them eat the leaves to a honey-comb, the damage lasting from two to four weeks. These larvæ are pale green in color with rows of small dots or tubercles running longitudinally along the body. When seen through the microscope, small fine hairs are readily noticed. When saw-flies become serious in a field, an

arsenate spray is advised, using 4 or 5 pounds arsenate of lead to 50 gallons of water. To make the spray stick better 1 pound of fish-oil soap may be used. This should be applied as soon as the young larvæ are noticed.

Riley succeeded in bringing out a number of parasites from the larvæ; this is probably one reason why the insect does no more damage. It is thought that the parasites, especially in the southern states where the winters are mild, will partially if not completely control this pest.

SWEET POTATO WEEVIL (Figs. 16–23)

Cylas formicarius

Within the last decade, by far the most serious insect pest of sweet potatoes has proven to be the sweet potato weevil. While this insect has been present in the United States since about 1879 and its ravages have been noticed locally in Texas, Louisiana and Florida, yet it was not until the beginning of the War when the whole world was looking to the United States for its food supply that the seriousness of this pest was recognized.

In 1917 the Bureau of Entomology started investigations with the idea of control and in some instances eradication. This insect was found in Texas, Louisiana, Mississippi, Alabama, Florida and Georgia, and also our insular possessions. It is estimated that Texas in 1917 raised $9,000,000 worth of sweet potatoes and suffered a loss of 20 per cent, or $1,800,000. Louisiana, with a crop valued at $5,000,000 lost 12 per cent, or $600,000, and Florida with a $4,000,000 crop lost $400,000 worth. Thus it will be seen that the loss in the southern states is about $3,000,000 or $4,000,-

000. Fortunately, this insect is confined to the six southern states just named; in Texas about seventy counties in the southeastern section are infested; in Louisiana most of the parishes south of Vernon Parish; in Mississippi, Hancock County, Harrison County, Jackson County and part of Pearl River County; in Georgia, Charlton County; and in Florida a great number of counties down both the east and west coast. In all of these sections the weevil is found breeding the year round on potatoes in the field, the tubers in storage and also on certain species of sea-side morning-glories and some species of bindweed. Infestation in the spring usually takes place through the over-wintered weevil. Weevils may pass the winter in three ways: First, in storage; second, in roots left in the ground from volunteers; third, in those left through poor harvesting. Weevils in all stages may be found in buried sweet potatoes along the Coast during the winter. In nearly all instances, infestation can be traced to mechanical means of transportation. By this is meant the selling and giving away of seed potatoes, plants, draws or vines, or in carelessly shipping potatoes for commercial purposes. All sweet potato growers or dealers and the transportation companies should be warned against this danger. Sweet potatoes or plants for propagation purposes should be carefully examined before being shipped, and no such material should be accepted from a weevil-infested area. To meet such conditions, state quarantine regulations should be placed in effect that will compel the small grower either to take care of his own crop or to permit it to be destroyed in case of severe infestation of weevil.

While it is not known definitely how much cold this insect can withstand, it is reasonable to suppose that if it should be transported to the northern states it would be protected from the cold winters by being housed with the potatoes. It is a prevailing opinion that while the insects would probably freeze out in the fields, the protection given to potatoes in storage will also protect the weevils and perpetuate them from year to year.

Description.

The adult of the sweet potato weevil is a snout beetle of an ant-like appearance, about ¼ inch long, with metallic blue wing-covers, the thorax brick red, head dark blue, and the legs brick red. The antennæ are long and have clubs at the end. The male bears the longer larger club, thus distinguishing him from the female. The eggs are pale yellow, partially oval, and somewhat narrowed at the end which is attached to the potato. The surface is not shining or polished, but is granulated. The length is about 1/40 of an inch. The larva when full grown is cylindrical and robust; the segments are permanent and rounded, color practically pure

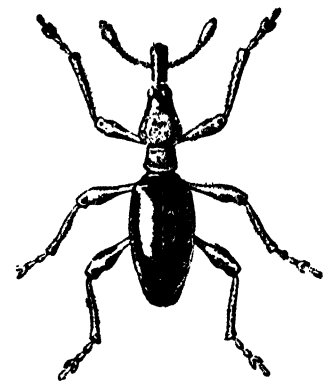

FIGURE 16.—The sweet potato weevil: Adult, greatly enlarged.

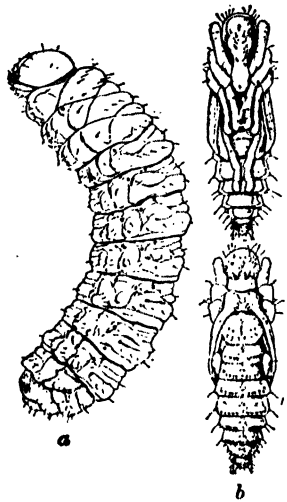

FIGURE 17.— The sweet potato weevil: *a*, larva; *b*, dorsal and ventral views of pupa. Enlarged.

white; head pale brown; mouth-parts a brownish shade; a few delicate hairs can be seen under the microscope. The larva is legless, although very thick leg pads are apparent (see Fig. 17). The length when grown is about ⅜ of an inch. The pupa is at first the same color as the larva, but before transformation to the adult becomes considerably darker. The wing pads are short and narrow, folded over the under side of the body; the head and back fold down upon the breast; on the head are several small tubercles, each one bearing a slender spine; it is about ⅛ of an inch long. The pupa is not active, not partaking of food. The lower half of the body is mobile, enabling the pupa to turn about in its burrow or pupa case.

Life history.

While it is thought that the sweet potato weevil passes through a part of the winter in hibernation, it is active throughout the entire year in the Gulf states. Eggs, larvæ, pupæ and adults may be found throughout the winter over its entire range.

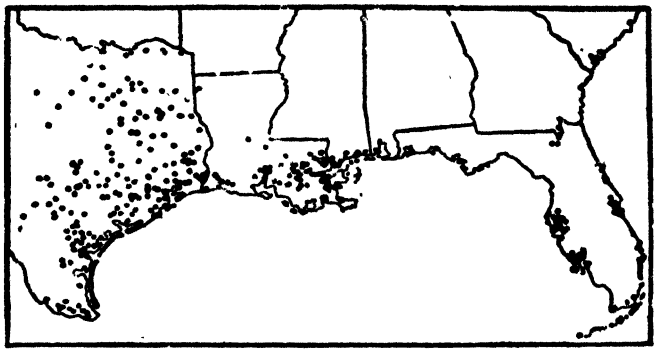

FIGURE 18.— Present known distribution of the sweet potato weevil in the southern United States.

From observations made by authorities, very little egg-laying takes place during the winter, but the adults are active on warm days and are frequently found crawling about and feeding on stored potatoes. In the spring and in the field the beetles become much

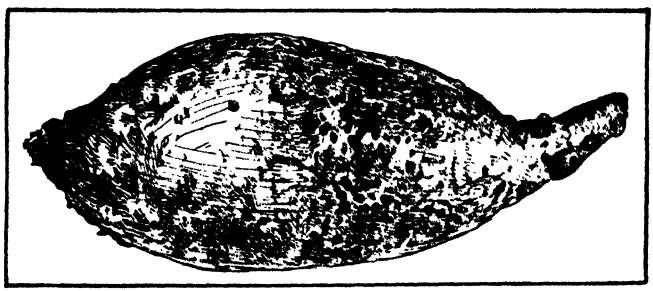

FIGURE 19.— Sweet potato, nearly fresh, showing exit holes and feeding punctures of sweet potato weevil toward stem. Note outer end scarcely attacked. Sample from Louisiana.

more active. Frequently potatoes in storage that have been little affected during the winter may be entirely riddled in the two spring months. In the field or drawbed, the beetles first feed on leaves and the stems of

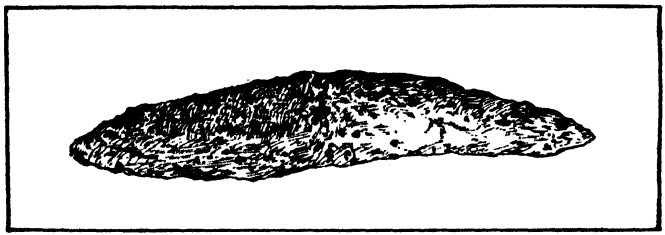

FIGURE 20.— Sweet potato badly infested by sweet potato weevil, decidedly dry, but showing break at middle where living larvæ, pupæ, and adults were found. Somewhat reduced.

the young plants, eating or gnawing irregular holes and excavations in them. After the plants reach a sufficient size to become woody, the eggs are deposited on the stem near the surface of the ground. If the ground is loose or cracked from the baking sun, the female will follow the vine down as far as possible and deposit her eggs there. If the tubers themselves are exposed to the surface, eggs are usually deposited on them. The young larva eats into the potato, leaving an irregular tunnel or furrow filled with excrement. They burrow and feed throughout the winter until their full growth is reached, when they form an oval cavity or pupal cell, usually near the surface of the potato, in which they pupate. In cases in which the eggs are deposited on the vines in the field, the larvæ bore down the stem until they reach the potato and

enter it. In this way the upper portion or the end attached to the vine is always attacked first. After the beetles emerge from pupation, they break irregular

FIGURE 21.— Cross-section of sweet potato showing injury by sweet potato weevil. Larva in burrow at top; pupa below; opening to tunnels elsewhere. Enlarged three diameters.

openings in the skin of the potato which are much larger than either feeding or egg punctures. As the attacks progress and the infestation becomes serious, especially if in storage, the tubers develop a tendency to dry out and shrivel. In some cases of excessive moisture or being bruised, the potatoes are affected with brown-rot and often decay, causing the death of the weevils. If the potatoes become extraordinarily hard and dry, the newly emerged adults cannot push their way to the surface and are thus confined in their cells and die.

M. M. High,[1] who has been investigating the weevil

[1] Farmers' Bull., U. S. Dept. Agr.

in south Texas, gives the following figures in reference to the life history: A single female has been known to deposit more than 300 eggs, as many as ten in a single night, the process of laying a single egg being

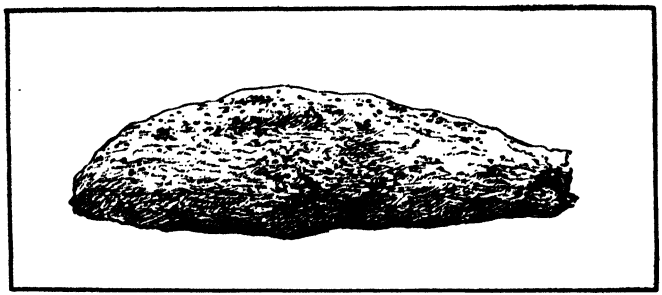

FIGURE 22.— Sweet potato beginning to dry, showing punctures made by the sweet potato weevil, chiefly for food. Interior highly infested and root much shrunken.

quite protracted. The eggs are not laid in feeding punctures but in cavities bored especially for them. These holes are usually at an angle of about sixty degrees, while the feeding punctures are practically perpendicular. Transformation from egg to adult lasts, in warm weather, about thirty days, and in cooler weather as many as forty-two days, or a longer length of time, varying with temperature. The pupa period lasts eight or ten days; the egg four to eight, and the larva or feeding stage from fourteen to twenty-eight days.

Control.

The sweet potato weevil breeds exclusively on sweet potato and closely related plants, and although it is

provided with perfectly developed wings, it seldom is seen in flight and this method of spreading may be disregarded. Therefore, it must be assumed that the weevil can be controlled or held to a specified infestation by care in the transportation of sweet potatoes and by-products. It is possible that the weevil will crawl for a great distance; this being recognized, growers a few miles from infested farms need have very little fear of damage provided they take ordinary precautions.

Clean culture is the chief ally in fighting the weevil. The ground should be kept clean at all times, plants healthy and in good growing condition, and the land should not be allowed to bake or crack open during the summer. It is further recommended that the crop be put out later and harvested earlier than is usually the practice. This gives a shorter season for the plants and tubers to become infested in the field. At harvest time sweet potatoes should be divided into three lots: Weevil-free tubers; tubers slightly infested; tubers badly infested. The last lot should immediately be fed to the cattle or poultry after cooking, or should be burned. The second lot may be fumigated for immediate use; and the first stored for winter keeping. In this manner no direct loss will result from the infested potatoes, as they make valuable stock-feed. As soon as the potatoes are removed from the field, the vines should be raked into piles and burned, as soon as dry. Hogs should be turned into the field to eat all the small stringy potatoes and cut ones that are left. In this way tubers that might remain in the field during the winter will be destroyed, and the field will probably be freed of over-wintering weevils.

It is not advisable that potatoes be planted to the same land two years in succession. The crop for this year should be put as far as possible from last year's field. When the seed-bed is used, it is advised that the young plants be sprayed once or twice with arsenate of lead, 4 pounds to 50 gallons of water. Time may be saved by dipping the plants as they are pulled from the draw-bed. Some of the weevils while feeding on the young plants will be killed. This will effect a partial control in the field.

FIGURE 23.— Corner of a vacant lot in Florida showing mat of wild sweet potato vines badly infested with the sweet potato weevil.

So far as is known, no variety of potatoes is immune from the attack, although sweeter yellow varieties known in the South as yams are preferred, the Nancy Hall variety being one of the favorites.

It is especially advised in order to eradicate this insect from the farm that no seed potato bed be put out, but that plants be bought from some reliable dealer or firm that have had their plants inspected and tagged by a state official, certifying that they are free from all insect pests or plant diseases.

In the spring, as soon as the main stock of edible potatoes has been disposed of, the old store-house or bin should be cleaned up thoroughly. In this way several weeks should elapse between the date of cleaning up and that of setting out new plants. If any adult weevils should be left, it is believed that they will be starved before this new food supply is brought in.

CHAPTER VIII

DISEASES OF THE SWEET POTATO

THE sweet potato grower has to contend with comparatively few diseases that could not be prevented or cured if a little time and labor were expended. The small farmer is chiefly troubled by storage rots, while the large grower, who has a dry house which will largely prevent these rots, will have to fight diseases in the field.

The practice of selling in the fall as soon as potatoes are harvested has been brought about by the conditions prevailing in the "bank" or "pit." Farmers have been accustomed to rush their product on the market before the fatal rot sets in. It is estimated that only about 50 per cent of the potatoes produced are consumed; the other 50 per cent decaying from some one of the storage rots.

In the field some of the diseases can be destroyed by spraying, but in certain cases crop rotation, change of seed or draws and good cultural methods are the only control measures that can be advised.

The sweet potato troubles may be divided into the following general classes: Seed and draw-bed; field diseases, of tuber, stems and leaves; storage rots; decay from mechanical causes as age, frost, excessive heat and cold, handling at harvest, culling and grading for shipment.

STEM-ROT (WILT, BLUE-STEM) (Plate V)

Stem-rot, caused by the fungi *Fusarium batatatis* and *F. hyperoxysporum,* varies somewhat in appearance with different varieties. The first indication of the disease in the field is the dull color of the leaves affected. They finally become yellowed between the veins and somewhat distorted, these symptoms being followed by wilting. On pinching open the stem of a diseased plant, it will be found to be blackened inside. This discoloration sometimes extends several feet from the hill. Later the surface of the stem roughens and ruptures and becomes blackened and rotted. The organism that causes stem-rot may also attack the roots, forming a blackened ring about ¼ inch beneath the surface. If such potatoes are used for seed, diseased sprouts are likely to be developed therefrom.

In the seed-bed, the symptoms of the disease are similar to those in the field. Diseased draws can be detected by the faint discoloration of the foliage and the purplish tint in the tender white stem.

Stem-rot is know to be prevalent in New Jersey, Delaware, Maryland, Virginia, Illinois, Iowa, Kansas, Alabama, and Arkansas, and to be present in Missouri, North Carolina, Ohio, Georgia, Texas, Oklahoma, and Mississippi. It is probable that the disease occurs in other states also. In some sections the disease is at present relatively unimportant, owing to the fact that varieties have been grown which are somewhat resistant to it or that the sweet potato industry is comparatively new and the disease has not yet become serious.

It is not definitely known how long the stem-rot fungus will live in the soil in the absence of sweet

potatoes, but probably for several years. For that reason, sweet potatoes should not be planted on the same ground oftener than once in three or four years. It is very doubtful whether that length of time will completely eradicate the fungus, but it certainly will greatly reduce it. No other crops are known to be attacked by the stem-rot fungus; therefore, any crops commonly grown in the region may be used in the rotation.

It is important that all seed potatoes and commercially grown draws should come from reliable dealers and accompanied by a certificate stating that the potatoes or draws are free from all serious diseases.

Control of stem-rot.

As has already been pointed out, the fungus invades the potato. Consequently if diseased potatoes are bedded out, diseased sprouts or draws may be expected, as the fungus will pass from the tuber to the stem of the young plant. In the early stages these diseased plants are hard to detect, and many will be set out in the field where the growth of the fungus will continue. In the spring the seed potatoes should be disinfected just before bedding by treating for five to ten minutes in a solution made by dissolving 1 ounce of corrosive sublimate in 8 gallons of water. Only wooden vessels should be used for disinfection. Corrosive sublimate is a strong poison and should be kept out of the reach of animals. After the potatoes are disinfected they should be rinsed in pure water and laid in the sun to dry. This treatment will not kill the stem-rot fungus within the potato, but it will destroy any spores that may be on the surface. The solution of corrosive

sublimate should not be used more than two or three times, since it loses its effectiveness after repeated use. If for any reason corrosive sublimate can not be used, the potatoes may be immersed for five minutes in a solution of formaldehyde made by adding 1 pint of commercial formalin to 30 gallons of water. They should be rinsed in water and dried before bedding.

The continued use of the same soil for the seed-bed year after year is the chief source of many of the diseases of sweet potatoes. A change of bedding soil or ground should be practiced each year. In fact, clean sand hauled in from the woods is one of the best materials to use in the bed. Stable manure is not essential to the production of healthy draws and is much more likely to become infected with disease germs than this fresh new sand. Many farmers throw aside the diseased potatoes as they bed down the good ones; fowls or dogs running loose around the place will easily take the disease to the bed on their feet. All such carelessness should be strictly avoided.

FOOT-ROT (Plates VI and VII)

(*Plenodomus destruens*)

Of the various diseases to which the sweet potato is subject, foot-rot (die-off) is one of the most serious. In the field, foot-rot first manifests itself as dark spots or areas at the base of the stem. The diseased areas may extend from 1 to 5 or 6 inches up the stem, the remainder appearing more or less normal. The tissues within the diseased area of the stem are killed and the fruiting bodies of fungus develop below the surface. The woody part of the stem becomes blackened and

PLATE VI.— Sweet potato foot-rot. *a*, The lower part of a sweet potato plant killed by the foot-rot fungus. *b*, A sweet potato rotted by the foot-rot fungus. Note the fruiting bodies crowded together over the surface.

dried out. In the seed-bed, the young sprouts shrivel and turn black near the surface of the ground extending a few inches up the stem. The young draws look weak and discolored and finally die in severe cases. The tubers are usually attacked from one end and shrivel and dry up, the disease gradually working back toward the other end.

Foot-rot is distributed in the same way as stem-rot and black-rot, through diseased soil, exchange of plants or seed potatoes.

Foot-rot is known in Virginia, Iowa, and Missouri, and it is probable that it occurs elsewhere.

Owing to the fact that it is not so widely distributed, the total loss that may be attributed to this disease is much less than with black-rot and stem-rot. In localities where it does occur, however, it produces greater loss than either of those diseases. In certain sections of Virginia, Ohio, and Iowa, it has been estimated to produce a loss of 50 per cent of the crop in one year.

The same control measures should be applied for this disease as for stem-rot and black-rot: — namely, seed selection, clean seed-beds, and crop rotation.

ROOT-ROT (Plate VII)

(*Ozonium omnivorum*)

This disease is best known as the Texas root-rot of cotton and alfalfa. The causal organism gains access to the plants on the underground parts and spreads in both directions, invading the vines for 6 to 12 inches above the ground. It may enter the potato at the end or form lesions of varying sizes on the surface. In

either case a firm brown rot is produced, resulting in the complete destruction of the potato (Plate VII). Above ground the growth is within the stem and may be detected by the brown discoloration produced. The organism lives from one season to the next in the soil on dead vegetable matter, or in the far South probably on growing winter crops. It is killed by hard freezing, and this alone probably restricts the fungus to the southern states.

Root-rot, so far as known, occurs only in Texas, New Mexico, Oklahoma, and Arizona. When the disease once gets into a field, a whole crop may be destroyed. Large fields have been seen in which not more than 10 per cent of a crop was produced. Viewed from a distance, the fields looked promising, but when harvested the potatoes were nearly all found to be destroyed by the fungus.

While it may now be considered a southwestern disease, it may be expected to spread to the eastern, southeastern, and northern states, if rigid inspection and quarantine measures are not observed.

Root-rot is worse on heavy soils and potatoes should be planted on light well-drained soil. The disease has a great variety of host plants and is particularly hard to control on this account. Deep, clean cultivation and crop rotation are essential. Disease-free seed should be selected, a rotation practiced with corn or other cereals as the disease is not known to attack these crops.

BLACK-ROT (BLACK-SHANK) (Plates V, VII)
(*Sphaeronema fimbriatum*)

Black-rot may occur on any of the underground parts of a plant. The disease is characterized by nearly

black. sunken, circular spots on the surface. In the early stages the spots appear as nearly round, but they become larger and lose their shape somewhat. Frequently nearly the whole of a potato is covered by this disease. The tissues beneath the surface have a greenish tint, while the surface of the spot itself is often metallic in luster. On the plants the disease begins as small round spots and continues to grow until the whole stem of the plant is rotted off. Frequently it extends up the stem to the surface of the soil but never above.

Black-rot was reported the first time in 1890 in New Jersey, but it is probable that it occurred long before that. Since then it has been found in practically every part of the United States where sweet potatoes are grown and also in the West Indies and New Zealand.

The disease is known in New Jersey, Delaware, Maryland, Virginia, Ohio, Illinois, Missouri, Iowa, Oklahoma, Texas, Arkansas, North Carolina, South Carolina, Georgia, and Alabama, and it is possible that it occurs wherever sweet potatoes are grown. Black-rot has been found on the following varieties: Nancy Hall, Yellow Jersey, Big-Stem Jersey, Red Bermuda, Miles Yam, White Yam, Southern Queen, Pierson, Early Red Carolina, Florida, Yellow Strasburg, Key West Yam, Red Jersey, Dahomey, Red Brazilian, Yellow Yam, Vineless Yam, and Georgia.

In all the regions mentioned, the disease is prevalent on the plants or slips in the hotbed and on the potatoes in the storage-houses in the winter; in fact, heavy losses are caused by this disease in storage-houses, where it develops freely under favorable conditions and renders the potatoes unfit for consumption.

The same control methods in general should be ap-

plied to black-rot as to stem-rot, particularly the preparation of the hotbed. If black-rot alone is concerned, the seed may be selected in the spring instead of in the fall. If selected in the fall, it should be picked over again in the spring and any potatoes with suspicious spots on them discarded.

The treatment of the soil with sulfur, lime, gypsum, or different fertilizers has little or no effect on the disease. Dipping the slips in a solution of bordeaux mixture or in a lime-sulfur mixture just before setting them in the field does not prevent the disease, but has been found greatly to injure the plants.

SCURF (SOIL-STAIN, SOIL-SPLOTCH, RUST, JERSEY MARK)

Scurf is characterized by a brown discoloration of the surface of the underground parts of the sweet potato plant. (Plates V, VII.) The discolored areas may take the form of spots of varying sizes and shapes with no definite outline or there may be a uniform rusting of the entire surface of the potato. The scurf produces no rupture of the sweet potato and is so superficial as to be scraped off easily by the finger-nail.

Scurf is widely spread over the sweet potato area.

To control this disease, the seed potatoes should be disinfected for ten minutes in a solution made by dissolving 1 ounce of mercuric chlorid (corrosive sublimate) in 8 gallons of water. They should then be dipped in water and dried. Soil or sand obtained from the woods or from fields where sweet potatoes have never been grown should be used in the hotbed. The plants should be set in new ground or ground never before employed for sweet potatoes.

Scurf is worse on heavy soils and on those contain-

ing a large quantity of organic matter, such as manure. Such soils should be avoided. It is likewise more serious during a wet season and on low wet ground. The treatment of the soil with fungicides or fertilizers has not been effective as a means of control.

LEAF-BLIGHT (Plate VIII)

(*Phyllosticta batatas*)

Leaf-blight appears on the upper side of the leaves, either as roundish or angular spots. These vary in size from ⅛ to ½ inch in diameter and are defined by a distinct line around them. Within the spot are several blotches or dark patches which are caused by the spores of the disease. So far it is not known that this disease is parasitic on any other plant and only on the leaves of potatoes. It is thought to live over the winter on the dead leaves. The disease usually manifests itself on the mature leaves.

Leaf-blight occurs principally in the southern states, rarely appearing on the east coast north of Virginia, or in Iowa, Illinois, and Kansas. So far the disease has not been of enough consequence to justify treatment.

LEAF-SPOT (Plate VIII)

(*Septoria bataticola*)

This fungus is similar in general appearance to leaf-blight. It manifests itself in the form of spots ⅛ to ¼ inch in diameter; these spots are scattered promiscuously over the foliage. They are white surrounded by a brown border. In the center of these spots are dark areas very similar to the ones described in leaf-blight. These are the clusters of spores before they are released

to scatter to other sections of the leaves. This disease is not known on other host plants and only on the leaves of the sweet potato plant. It probably winters on the dead leaves, and may be transmitted by insects, wind, or rain.

Leaf-spot is widely distributed, having been collected from the eastern coast and also from the states of Iowa and Illinois. This disease has never been known to be serious; no remedies are required.

WHITE-RUST (LEAF-MOLD)

(*Albugo ipomœæ-panduranæ*)

The first symptom of white-rust is a loss of the green color in the indefinite spots on the under side of the leaf. (Plate VIII.) Later these spots become brown and covered with a whitish viscid growth, which is finally more or less powdery. This white powdery mass is made up of numerous spores or reproductive bodies, which serve to start a new infection if they fall on another leaf and conditions are favorable, such as high temperature and relatively high humidity. Frequent rains and heavy dews are favorable to the spread of this disease. No great harm results from the attack of this fungus, although it may sometimes produce swellings on the stems and petioles and malformations of the leaves. White-rust is much more prevalent in wet weather. It is widely spread, having been found in both the eastern and the central section.

SOFT-ROT (Plate V)

(*Rhizopus nigricans*)

Soft-rot is the most destructive of the storage diseases; in fact, it is claimed by many to be more injurious than all others combined. This is the bread-mold which is so common everywhere. The decay begins at one end of the potato or at a cut or bruise and spreads rapidly throughout the whole of the tuber, a day or so being long enough under high temperature and humidity. Soft-rot sets in soon after the potatoes are harvested and stored and continues more or less throughout the fall and winter season. As long as the skin of the potato remains unbroken, the fungus does not ordinarily produce spores; but in the presence of a cut or bruise, fruiting stalks are pushed up and thousands of spores are produced. As soon as these come in contact with the other potatoes, the trouble begins. They may be spread by insects, wind or rain.

Owing to the abundance of the spores of this fungus, little can be done to control it except careful handling of tubers at harvest. Potatoes should not be put on heavy poorly drained soil.

RING-ROT (Plate VII)

(*Rhizopus nigricans*)

Ring-rot is caused by the same mold as soft-rot. The two diseases are very similar except that ring-rot attacks the potato nearer the middle instead of the end and forms a distinct ring around the tuber. This ring varies in width from about 1 to 3 inches. In high temperature and humidity, the whole potato may often be

destroyed. The same precautions should be used for this form of the disease as for soft-rot.

DRY-ROT (Plates VII, VIII)

(*Diaporthe batatatis*)

This rot begins at one end and slowly works toward the middle of the potato or to the other end. This results in a firm hard brown rot which causes the potato to look dry and mummified. Small dome-like bumps are just noticeable to the naked eye; if the outer surface of the skin is scratched away, the tissues beneath present a coal black appearance. In the small protuberances on the surface are to be found millions of colorless spores, which serve to reproduce the fungus.

While dry-rot attacks the stems of the plants in the field and draw-bed as well as in the storage-house, yet it is by no means the most serious of the rots. It is widely distributed throughout the country, and usually does some damage wherever found.

JAVA BLACK-ROT (Plate VII)

(*Diplodia tubericola*)

This rot receives its name from its first discovery in this country on a shipment of sweet potatoes imported from Java. The disease is widely distributed, but is most common in the South. Potatoes attacked by this disease become dry, hard, brittle, coal black inside, and hard to break. Java black-rot usually begins at one end and develops very slowly, requiring several weeks completely to destroy a tuber. The surface of the potato is very rough, the skin becoming wrinkled and knots or protuberances abundant over it.

CHARCOAL-ROT

(*Sclerotium bataticola*)

A rot of less economic importance is occasionally found in the storage-houses throughout the country, which likewise produces a black decay. This form of rot differs from others of a similar appearance by the production by the fungus of minute spherical resting bodies throughout the potato, rarely on the surface. These bodies are coal black and stand mostly separated from each other. If the surface of the potato is carefully opened, these bodies can be seen by the naked eye buried in the tissue. Some shrinking and drying of the potato follow an infection by this fungus. The total loss to the crop that might be attributed to this disease is comparatively small.

CONTROL OF STORAGE ROTS

In 1918 the writer treated a quantity of stored sweet potatoes at Ocean Springs, Mississippi, in the following way: The decaying potatoes were culled out and the surfaces of the remaining good ones were sprayed with a 4–4–50 solution of bordeaux mixture. The results were very gratifying. Of course it is necessary to have plenty of air in the store-house until the surplus water on the surface is dried off. However, in most cases it is best to adhere to the following instructions taken from a United States bulletin:

"The United States could and would produce many more sweet potatoes if they could be marketed at a fair profit. One of the chief barriers to the extension of the industry is the inability of the farmers to keep the potatoes in storage so that they can be placed on the

market in the winter, when prices are good. As a result most of the potatoes in the South are consumed locally and placed on the market at digging time, when prices are low. Consequently, few sweet potatoes go on the northern markets in the winter, and even in the South where they are grown they can not be obtained with any degree of certainty at that season of the year. It is believed that if storage methods and principles were better understood, more potatoes would be available for winter use and disposed of at good prices.

"The success of the industry, however, does not depend on successful storage methods alone. It is a well-known fact that there are several field diseases of the sweet potato, the best known of which are black-rot, stem-rot and foot-rot. The storage of black-rot potatoes must necessarily result in heavy loss, since the disease spreads rapidly throughout the bins. Stem-rot on the other hand, does not produce any marked decay in storage, but it may open the way for storage-rot organisms to enter the potato. It therefore becomes imperative that the elimination of the field diseases must be coupled with a well-regulated system of storage.

"Great care should be exercised in handling sweet potatoes not to bruise them any more than necessary. The bruises made by rough handling open the way for storage-rot organisms to enter. A farmer would never think of handling apples, oranges, or any of the fruits in the way that sweet potatoes are handled, and yet a barrel of good sweet potatoes will bring as much on the market, and often more than a barrel of good apples, and sweet potatoes bruise even more readily than apples. It is likely that if sweet potatoes were handled with the same care and intelligence as apples, little difficulty

would be experienced in keeping them in storage.

"After the potatoes are well dried in the field they should be carefully laid in an open crate holding about a bushel and hauled to the storage house. They should not be poured out of this crate into a bin, but stored in the crate itself. The use of crates permits the free circulation of air among the potatoes, a condition which can not be obtained if they are piled in a bin. The crate has an added advantage in that, as many potatoes can be taken out for the market during the winter as are desired without disturbing the remainder. Sweet potatoes will not stand frequent handling, and for that reason it is unwise to disturb a pile or bin unless they are all marketed at the same time. The use of crates would eliminate this danger.

"Potatoes intended for storage should be dug as late in the fall as is consistent with weather conditions. This is usually just preceding frost. Frozen potatoes will not keep well, and it is likely that a heavy frost will injure them to some extent. It is advisable, too, after a heavy frost to cut the vines at once and dig. It is believed that warm, dry, sunny weather preceding a frost is better than a period a little later in the season following a frost. To wait too long may mean that in order to avoid freezes the potatoes must be dug during bad weather. After digging, the potatoes should be allowed to dry as long in the sun as is consistent with weather conditions. On a very hot day, however, it would be desirable to hurry the potatoes to the shade after their surfaces have been dried in the sun."

CHAPTER IX

INSECTICIDES, FUNGICIDES AND SPRAY MACHINERY

THE successful grower of sweet potatoes will be called on to administer preventatives and remedies for insect depredations and attacks of plant diseases. It is, therefore, necessary that he should be familiar with different chemicals used as poisons for insects and as remedies for plant diseases, and he should in addition have a general knowledge of the kinds of spray machinery and pumps with which to apply them.

Of course, there are many areas in many localities where remedies will not often be needed, but at certain times the grower will probably have to resort to spraying in order to control these pests and diseases. It is, therefore, thought necessary to give some information concerning the more important sprays, and the different forms of sprayers.

INSECTICIDES AND FUNGICIDES

Arsenate of lead is one of the commonest insecticides and the spray may be made as follows:

3 to 5 pounds of arsenate of lead.
1 pound of fish-oil soap.
50 gallons of water.

This makes an average solution that is commonly used

by most planters. The arsenate of lead and fish-oil soap should be dissolved in 2 or 3 gallons of water and this amount poured into the remainder of the 50 gallons and thoroughly stirred until the mixture is evenly dissolved. The fish-oil soap is added only as a sticker but it also gives a more even covering of the plants. However, this may be eliminated with all the sprays for all plants except those that have slick leaves. If powdered arsenate of lead is used, one-half the above amount should be mixed.

Paris green is a chemical compound of white arsenic copper oxide and acetic acid. The compound is known as aceto-arsenite of copper. When properly prepared, it should be of uniform composition and contain very little insoluble matter. This is a deadly poison and is very effective when used for biting insects. This should be prepared by dissolving 5 ounces of paris green and 50 gallons of water, and if desirable the fish-oil soap, as in the arsenate of lead preparation, may be used or left out, as it is only necessary for sticking. The grower must bear in mind that paris green will burn the plant much more readily than arsenate of lead. To prevent this burning, it is advisable that a small amount of hydrated lime, at least 2 pounds, be used in the spray. Paris green usually costs more than arsenate of lead and, considering its burning qualities, it is advisable to use the latter.

Arsenite of lime is easily prepared at home and is very effective. The proportions are:

White arsenic, 1 pound.
Crystal sal soda, 4 pounds.
Water, 1 gallon.

These ingredients should be placed in an iron vessel, and boiled for fifteen or twenty minutes or until thoroughly dissolved. Forty gallons of water should be added to 1 quart of this stock solution, and 3 pounds of freshly slacked lime. This solution is cheaper than the other arsenicals, and if properly prepared and applied is very satisfactory.

Tobacco decoction is prepared by boiling tobacco stems and other refuse of tobacco, 1 pound to 1 or 2 gallons of water. If any of the water evaporates while boiling, enough should be added to replace it. This solution is used for plant-lice and other delicate insects.

Black-leaf-40 or nicotine sulfate may be purchased from any reliable drug dealer, and it should be prepared by adding nicotine sulfate to water at the rate of 1 part to 1000. If a sticker is desired, fish-oil soap should be used as directed in other sprays. This spray is for plant-lice and other sucking insects.

Gold dust or laundry soap.— A good insecticide may be prepared by mixing 4 pounds of gold dust or common laundry soap to 50 gallons of water. When the soap is used, it should be shaved into fine slices and boiled in 1 or 2 gallons of water until thoroughly dissolved. This stock solution should then be poured into the proper amount of water and stirred or churned until it is dissolved.

Poison bran mash is prepared as follows:

1 pound paris green.
25 pounds wheat bran.
½ gallon cheap molasses.
½ dozen lemons or oranges.

The paris green and bran should be mixed thoroughly,

and the molasses mixed with 1 gallon water. The lemons or oranges should be chopped into very fine particles and put in the sirup and the poisoned bran moistened with the sirup until it makes a stiff mash. It should be applied very late in evening by putting one spoonful near each plant or by broadcasting over field. It is strongly recommended for cut-worms and army-worms.

Bordeaux mixture is used in combatting most fungous diseases and also repels certain insects, such as flea-beetles. It is prepared as follows:

Unslacked lime	4 pounds.
Copper sulfate (bluestone)	4 pounds.
Water	50 gallons.

The lime should be slacked in enough water to make a milk of lime solution, and the bluestone should be dissolved in water to take the amount in the formula. The bluestone solution should then be poured into the lime and this mixture diluted to the full 50 gallons strength. It is important that very cold water be used in preparing this spray, if possible ice water. The mixture should be kept in a very cool place. Bordeaux mixture may be combined with any of the insecticides, thus making a dual spray.

Carbon bisulfid is a fumigant and should not be applied to live plants of any kind. It is valuable as a storage product insecticide. It is bought from druggists in small tin packages or demijohns. It is a liquid and is applied by using 3 to 4 pounds of the material to 1000 cubic feet space for a period of 30 hours. It should always be placed in an open vessel on top of the material to be fumigated. To be effective, it must be

applied in a room or bin that is practically air-tight. Fire must be kept away as this is very inflammable.

SPRAY MACHINERY

Sprays are best applied by the use of proper instruments, a few of which will be discussed here. For the grower that has only a few rows, a small hand sprayer or atomizer may be used. These ordinarily hold about a quart and may be bought at almost any hardware store. These are usually of glass or tin.

Knapsack pumps are most suitable for the farmer who has a small patch, from one-half to several acres. These are usually made of galvanized iron or copper and are strapped on the back so that the operator pumps with one hand and holds the nozzle with the other.. They ordinarily hold from 2 to 4 gallons. The pump should have a good agitator or mixer. Bordeaux mixture will soon eat out the pump.

Compressed air sprayers are small, handy and very efficient. The capacity usually runs from 2 to 4 gallons, and a pressure of several pounds is maintained by a small air pump extending down into the tank. The spray is released by turning on the faucet near the nozzle. A tank of spray material may be applied with two or three pumpings. These are fitted with a strap so that they can be carried over the shoulder with ease. The top should be screwed on and not clamped on over a rubber gasket.

Barrel pumps are the most serviceable and popular for the average farm. Much more work can be accomplished with these, and very efficiently. These barrels hold from 50 to 60 gallons, and of course have to be

hauled through the field on a wagon, cart or slide. One man is needed to pump and keep up pressure, while another manages the nozzle. In buying a barrel pump, the following suggestions should be kept in mind: (1) The pump should be guaranteed to furnish 80 to 100 pounds of pressure with four nozzles running; (2) it should have a large air chamber within the barrel and not projecting above it; (3) as many working parts as possible should be inside the barrel, as exposed parts are easily broken; (4) the cylinder, plunger, valves, and all working parts should be made of brass, the handle and other parts of malleable or galvanized iron; (5) there should be a good mechanical agitator of the paddle type; (6) the pump should be so attached to the barrel that it may be quickly removed for repairs; (7) valves and their seats should be easily removable for cleaning.

Power outfits.— For the commercial growers who produce many acres, power outfits might be used. However, it should be ascertained first that the barrel type pump will not do the work. Power sprayers should be mounted on substantial trucks with wheels that may be set in or out to fit different width rows. These outfits should easily run six to eight nozzles so that several rows may be sprayed at the same time. All the working parts of the machinery should be easily accessible for repairs. Often the most simply constructed outfits give the best satisfaction. However, a cheap pump is not satisfactory and one should buy of a standard company.

Dusters.

Often dusting will answer the same purposes as spraying and the work can be done much faster. For the farmer who has a few acres, a simple duster or powder-

gun may be employed. This duster has tubes which will direct the dust on two rows, or on both sides of one row, and regulates the amount of dust used. Large power dusters are also on the market, but the average sweet potato grower would rarely need such an outfit.

When dusting is resorted to, it must be remembered that the material must be put into the finest form of powder possible. This is necessary in order that the leaves may be thoroughly covered. Coarser dust will not stick to the leaves and cover them as evenly as the finer kind, neither will it feed through the machine as satisfactorily. The chief advantage in dusting is in the time saved.

Nozzles, hose, and fixtures.

Three types of nozzles are the Bordeaux, Vermorel, and the Disk. For applying most of the ordinary insecticides and fungicides, the Vermorel and Disk are preferable. These make a cone-shaped spray.

For applying bordeaux mixture, the Bordeaux type is very satisfactory. This makes a fan-shaped spray.

The nozzle that can be easily taken apart and cleaned is the most desirable.

An angle-form nozzle or nozzles with elbow joints should be used in order that the spray may be applied to the under side of the leaves. A good quality rubber or fabric hose and good clamps should be used so that no leakage will occur. Where the hose bends near the pump or near the extension rod, it should be wrapped or supplemented with tape, or a good coil of wire around it, which acts as a supporter.

CHAPTER X

HARVESTING AND STORAGE

The harvesting and transportation of sweet potatoes to local and northern markets begins in August in the extreme southern section of the potato area. Along the Gulf, many potatoes are put on the market in the latter part of July. This is not a good practice, however, and is only due to the fancy prices that they command at this time. The yield, as a rule, is light at this season, as the potatoes have not attained their growth, and a considerable loss in weight results. The main supply of the crop for home and commercial purposes is harvested late in the fall, the usual time being about the first frost. When the potatoes are thoroughly matured, a slight yellowish tinge on the leaves and the absence of any new growth is noticeable. Another means which many growers find very reliable is to break a tuber in two; if ripe the broken part dries after a few minutes' exposure; if still green and in a growing state, the broken part remains milky and sticky.

While the sweet potato vines usually are very luxuriant, the foliage is tender and easily injured by frost. Light frost, however, causes very little injury, but a heavy frost or a light freeze may result in considerable damage, if the vines are not cut away immediately. This latter practice is to prevent the frost-injured sap from passing down to the tuber. In certain seasons

when potatoes cannot be dug at the first frost or at convenience, it is advisable to rake loose dirt over the rows and thus afford them protection from the cold.

The greater part of the farmers who raise only a small patch of potatoes for home consumption use various hand and horse-driven implements for digging. In fact, many tools from the ordinary hay-fork to the one-horse turning-plow are employed. When the fork is resorted to, the work will be easier and more satisfactory if a broad, flat, short-handled fork is used, one with eight to fourteen tines somewhat similar to the seed-fork.

When potatoes are dug by a turning-plow, it will be advisable to go twice through each row, turning the soil to both sides. By removing the mold-board and putting in several rods, either of wood or metal, the earth will sift through and leave the potatoes on the surface. In the larger fields it is advisable to use the regular potato-diggers manufactured for the purpose. These are usually the two- or three-horse plows; they have extension rods or fingers; while plowing up the row the soil sifts through and leaves the potatoes on top, where they may be easily picked up and put in the basket. In either the one- or two-horse plow, it is advisable to use the rolling cutting-colter, which cuts the vines and makes the plowing much easier. If the one-wing plow is employed, one colter is sufficient; if a double-winged plow, a double roller-colter is used to cut the vines from both sides of the row at once.

It is desirable that the soil should be comparatively dry at harvesting time in order that the potatoes may be drier and smoother and more satisfactorily handled. After the potatoes are plowed out, they should be allowed

to remain in the field until the surface and adhering soil are thoroughly dry. However, they should not be left long enough to sunburn or bake. In handling in the field, all the soil should be removed from the tubers. It is not advisable that they be left exposed to cool nights.

Whether the potatoes are for storage, home use or shipping, they should be crated in the field, thus eliminating one handling. The fewer handlings during harvest or storage, the less likely they are to become bruised and rot. If for storage, suitable baskets or hampers should be used; the first grade potatoes should be packed separately from the seconds or culls. If for shipping to market, either barrels or hampers should be provided.

STORAGE

One of the greatest limiting factors in the production of sweet potatoes for market has, until the present time, been the lack of proper storage facilities. In the fall at digging season when the bulk of this crop is offered for sale, the market is usually flooded and the price is correspondingly low; while during the spring and summer months, sweet potatoes are high in price and hard to obtain at any figure.

With the advent of the scientific storage-house, the fear of loss from rot is no longer justified and the fact that there is an all-year demand for sweets should be a great incentive to producers who avail themselves of efficient storage. In an effort to remedy this poor distribution and eliminate the unnecessary waste from decay by stimulating the erection of proper storage-houses and the correct manipulation of them, considerable work has recently been done by the United States

Department of Agriculture and also individual growers. This attention has been rewarded by the development of a very economical and efficient plan of storage which is in the reach of all growers. The future commercial development of the industry will no doubt be constructed on the basis of storage possibilities.

Essentials in keeping sweet potatoes.

To keep sweet potatoes successfully in storage so that they will not only be protected from decay while in the curing-house but will hold up well after being removed whether for shipping, seed purposes, or other uses, some essential principles must be carefully observed. In the first place, every precaution should be taken to prevent the spread of diseases, several of which seriously affect the sweet potato crop in storage. The time of digging and housing has been found to have a very marked influence over the keeping qualities of this crop. Extreme care in handling is absolutely essential if the potatoes are to be stored without bruises, which greatly interfere with their keeping qualities by facilitating the spread of numerous fungous diseases in the storage-house through breaks in the skins. It has been found that sweet potatoes should be well dried with warm dry air during the curing process and afterwards kept at a temperature ranging from 40° to 60° throughout the entire storage period. In keeping potatoes successfully, whether in a bank, storage-house or otherwise, it is essential that both proper insulation and ventilation be provided.

Care in hotbed for disease.— The successful curing and storage of sweet potatoes begins in the plant-bed. Too often little attention is paid to the kind of bedding

stock, and frequently sweet potatoes are used for seed purposes which are diseased when they are bedded. Such potatoes are sure to produce diseased plants, which in turn carry the disease to the field and often transmit them to the tubers. Black-rot is the commonest dis-

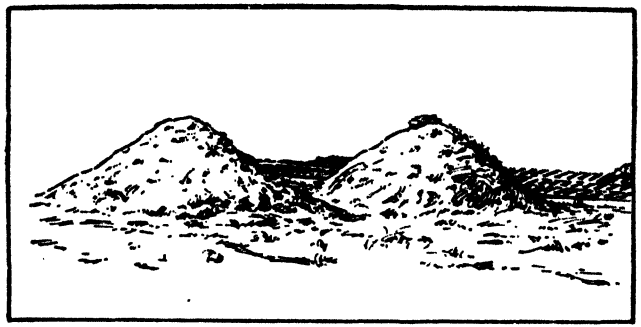

FIGURE 24.— Outdoor storage pits commonly used for keeping small quantities of sweet potatoes. Note proximity of pits to hotbeds, a bad location from the disease standpoint.

ease affecting the sweet potato conveyed in this manner. Such diseased potatoes will be difficult to keep under any conditions. (See Fig. 24.)

Vine and draw potatoes.— A very important means of controlling sweet potato diseases and preventing their spread is by the use of vines as a means of propagation. The general plan now followed by most successful growers is to plant a small seed patch with draws or plants, and from this first planting cut vines to set out the remaining acreage. In this way, no disease which might have been present in the plant-bed is carried to the field. Potatoes propagated by means of vines seem to keep better, generally speaking, than those

produced from draws or plants. This may be explained in several ways. In the first place, sweet potatoes produced from draws are likely to be planted early and are often left in the ground until they are overmature. When this condition exists, the late fall rains so prevalent in sweet potato growing sections are liable to injure the quality and consequently ease of keeping of these potatoes, which have already reached their maximum growth. Another reason for the apparent difficulty in keeping sweet potatoes grown from plants is that there is a greater tendency to produce large cracked-open jumbos, or as they are sometimes called "mother potatoes." In handling, these potatoes are more likely to become bruised and consequently will be more difficult to keep in good storage condition. Many growers very strongly recommend tubers grown from vines as being the best keepers.

Harvesting.— To secure the maximum yield and develop the highest quality in sweet potatoes, they should be allowed to mature before being harvested. Sweet potatoes which are planted early should not be left in the ground long after they are mature, since there is a tendency to produce ill-shaped jumbos which will have to be marketed at a disadvantage. Potatoes planted in midseason are ordinarily not mature until about the time of the first frost and the common practice is to let them remain in the field until this time. After frost has fallen, harvesting should be done immediately or if necessary to postpone it for a few days the vines should be cut off at once. It is well to get the potatoes out as soon as possible after the vines have been cut.

Care in handling.— One of the most important considerations to be kept in mind constantly if sweet pota-

toes are to be stored successfully is the method of handling. More potatoes are lost to the grower through careless handling and consequent bruises than perhaps any other one cause. No definite method of handling can be outlined, as individual cases necessarily require different methods, but whatever system of handling is used, sweet potatoes should never be thrown into heaps in the field, hauled loosely in a wagon body, or handled in sacks. A sack is the poorest container for handling potatoes, either in shipping or in storage. A large part of the potatoes handled in any of the above mentioned ways are sure to become bruised and the skins broken, which permit an easy entrance of diseases of all kinds. Sweet potatoes should be handled as little as possible, graded in the field, and carefully placed in boxes or baskets (preferably small bushel crates in which they will be stored). They should be hauled to storage in the same containers and thus bruises and consequent loss will be reduced to a minimum. Many yam varieties are more susceptible to bruising than such hardy kinds as the White Triumph and the Hayman.

Curing and storing.— Whether sweet potatoes are stored in a bank or a house, they should be given proper insulation and thorough ventilation. Insulation provides conditions which will prevent freezing. In a bank, insulation is provided by heaping earth several inches deep over the potatoes; in a storage-house by a dead air space in a double wall. In a bank, ventilation is secured by a ventilator in the top and sometimes others. When sweet potatoes are first harvested they contain excess moisture which is given off; if this excess moisture is not carried out of the storage-room by a

thorough circulation of air, it will collect on the outside of the potatoes and on the walls of the room, thus causing a humid condition and favoring the spread of storage diseases. This condition is especially suited to the growth and spread of ordinary bread mold, which is present everywhere and which destroys a larger part of the sweet potato crop in the form of soft-rot or ring-rot. To prevent the condition just outlined, it is abso-

FIGURE 25.— A pile of sweet potatoes to be covered with cane tops and soil. Note the absence of ventilating hole which should extend through the center of the pile.

lutely essential that thorough ventilation be secured which will carry the surplus moisture out of the storage-room, whether it be a bank or a house. It has been found that the proper ventilation and the desired temperature can be more easily, economically, and surely secured by using a properly constructed and operated storage-house than by the use of a potato bank. (See Fig. 25.)

Advantages of the storage-house over the bank.

The storage-house has a great advantage over the bank in that the two main essentials in keeping sweet potatoes (proper temperature and ventilation) can be regulated. In a storage-house this is done by means of artificial heat and specially constructed flues, ventilators and windows, whereas in a bank, ventilation must be depended on entirely, by means of an apparatus which cannot be controlled conveniently. Often sweet potatoes may be kept very successfully in a bank, especially in a dry year when potatoes do not contain an unusually large amount of surplus sap, or if very careful attention is given to the control of ventilators in the bank when conditions are ideal. In some years nearly all sweet potatoes are lost by soft-rot, which spreads very rapidly.

A maintenance of the proper temperature during the storage period, after the potatoes have been cured, is very important. Such a temperature can easily be maintained in a properly constructed storage-house, while it is very difficult to accomplish with the bank method, especially in freezing weather when the cold is likely to penetrate the bank, thus chill the potatoes and cause them to decay.

Even though the bank method were satisfactory in other respects, the extra cost of building these banks each year and the expense involved in moving the potatoes from such storage, especially in bad weather, makes them very uneconomical. To show the economy of a permanent house over temporary banks, even when the loss from rot in the house is as much as that in a bank, the following record is given of a house actually operated in south Mississippi during 1918. It should not

be concluded from these figures that a loss of 30 per cent from rot is representative of the efficiency of a properly operated storage-house; in reality, well-constructed and operated houses will keep sweet potatoes with practically no loss from rot. The figures on this inefficient house are given to emphasize the economy even under adverse conditions.

On December 15, 1259 bushels of sweet potatoes were stored in a 2000-bushel house. The cost of storage was:

$62.95	Estimated cost of handling 1259 bushels at 5 cents a bushel.
48.00	Interest on $600.00, value of the house, at 8 per cent for one year.
30.00	Annual depreciation in value of house costing $600.00.
12.00	Cost of three cords wood used in curing potatoes.
282.75	Loss from rot and shrinkage. 30 per cent of 1259 bushels valued at 75 cents a bushel at time of storing.
12.50	Interest on investment of 1259 bushels of potatoes valued at 75 cents a bushel.
$448.20	Total cost of storing 1259 bushels potatoes.
944.25	Value of 1259 bushels potatoes at time of storing at 75 cents a bushel.
$1,392.45	Total cost of potatoes stored.

537 bushels	sold at $2.00 net	$1,074.00
125 bushels	seed potatoes on hand valued at $2.00	250.00
80 bushels	culls on hand valued at 70 cents	56.00
100 bushels	fed to stock valued at 70 cents	70.00
20 bushels	sold on local market at $1.00	20.00
20 bushels	used at home valued at $1.00	20.00
377 bushels	lost by rot and shrinkage	

1,259 bushels total — Brought when sold.....$1,490.00
Total cost of 1259 bushels... 1.392.45

Profit by storing... ..... $97.55

Estimating the cost of putting this same 1259 bushels of potatoes up in banks, the following figures are given on fifty banks holding 25 bushels each, with the exception of one which would contain 34 bushels:

$62.95	Estimated cost of handling 1259 bushels at 5 cents a bushel.
282.75	Loss from rot and shrinkage. 30 per cent of 1259 bushels at 75 cents a bushel at time of storing.
12.50	Interest on investment of 1259 bushels valued at 75 cents a bushel at time of storing.
222.50	Estimated cost of putting up fifty banks of potatoes — forty-nine banks containing 25 bushels and one bank containing 34 bushels — $4.45 a bank.
5.93	Interest on money invested in bank material, $222.50, at 8 per cent for four months, the average banking period.
$586.63	Total estimated cost of storing 1259 bushels of potatoes in banks.
944.25	Value of these potatoes at 75 cents a bushel.
$1,530.88	Total cost of potatoes if they were stored in banks.
1,490.00	Actual selling price of the potatoes.
$40.88	Money lost by storing potatoes in banks, if they were just as efficient as houses.

Five cents a bushel was estimated as being the cost of removing the potatoes from the storage-house. It is computed that the cost of putting potatoes in the house would be approximately the same as loading them on car to ship when dry, thus offsetting expense of filling

the house. In this connection it will be noted that 377 bushels is the estimated loss of 30 per cent from shrinkage and rot, and yet the cost of removing potatoes was figured at 5 cents a bushel on the full 1259 bushels originally stored. This is thought fair because of the extra trouble involved in removing and disposing of the rotten stock.

In comparing storage methods, no difference was made in the cost for removing from bank and from storage-house. However, it is universally agreed by those who have used the house that this expense is considerably less than with the bank.

Attention is called to the fact that interest on house investment was charged for full twelve months, while on the bank only for the period of storage. In making this comparison, it must be remembered that the potato house makes an excellent store-room for articles other than potatoes during the other six or eight months of the year.

In computing depreciation, the value of the house was considered as remaining constant, while in reality if the house depreciated 5 per cent annually, this value would be $30.00 less the second year, the third year $28.50 less than the second, and so on, thus making the depreciation in actual money value less each year. The banks were considered as having to be made new each season, and were estimated at costing $4.45 each, using low-grade lumber at $30.00 per M (not including a board shelter for them) and calculating labor involved in building and hauling pine straw.

It will be noticed that the loss from shrinkage and rot is calculated on the basis of being equal. The actual shrinkage in a bank would be a little less but the loss from rot under the same condition would unquestionably

PLATE VII.— Sweet potato diseases. *a*, Sweet potato showing the characteristic shriveling produced by the root-rot fungus. *b*, A sweet potato showing discoloration caused by the scurf fungus. *c* and *d*, Showing ring-rot, frequently found in storage-houses. *e*, Java black-rot. A sweet potato showing the dry mummied condition produced by the fungus. Note the numerous pimple-like protuberances containing spores borne on the surface. *f*, Foot-rot. *g*, Dry-rot. *h*, Black-rot. A sweet potato showing the black circular spot caused by black-rot fungus.

have been considerably greater.[1] The loss from rot would have been much reduced if the potatoes had been dug and stored one month earlier.

The cost of all operations is calculated on the basis of $4.00 a day for team and wagon and $3.00 a day for man labor.

That a storage-house built by government specifications and operated according to government recommendations will keep sweet potatoes in storage in much better condition and do it more economically than will a bank, has been demonstrated on a number of farms in the past year throughout the entire South.

Construction of the storage-house (Figs. 26–30).

Many types of storage-houses are now in operation. The first storage place was perhaps a cellar under ground in which potatoes were kept during the winter. Next came a potato house level with the top of the ground, using the soil as a natural floor, filling the hollow walls with earth or other filling to prevent freezing. In this house a stove was sometimes installed to facilitate drying. This was a great improvement over either the pit, cellar, or bank, for being above the ground it was afforded drainage and ventilation, the expense of moving potatoes from storage was lessened and the use of artificial heat was gained. Since this first type of house was built, errors have been corrected, experiments have been conducted and improvements made.

The best type of house for the individual farmer who wishes to store from 500 to 5000 bushels of potatoes is

[1] Ala. Exp. Sta., which shows a loss of $8,946,000, representing 10 per cent loss from field diseases and 50 per cent from rot in storage of sweet potatoes in 1918.

the one herein illustrated and described known as the government sweet potato storage-house. It is now concluded by some experiment stations that any house having a capacity above 5000 bushels should be heated by hot water or some other system which will give an even distribution of temperature in all parts of the house. Various commercial concerns have endeavored to make improvements on these large houses, and several patented curing processes are now being promoted with some success.

A sweet potato storage-house should be located on a well-drained spot. If a commercial house, it should be near the railroad and as convenient to the field as possible. If for home use, it could be conveniently situated in the back yard, so as to be readily accessible at all times.

Details of the construction of the sweet potato storage-house are reprinted from Farmers' Bulletin 970:

"Sweet potato storage houses may be built of wood, brick, hollow tile, cement, or stone. Wooden houses are preferable, because they are cheaper and easier to keep dry than the other types. It is difficult to keep moisture from collecting on the walls of a cement, stone, or brick house. Where such houses are built for sweet-potato storage they should be lined with lumber, so as to keep the air in the house from coming in contact with the masonry walls. It is best to build sweet-potato storage houses on foundations that allow a circulation of air under them. The "dugout" or house built partly under the ground, is not satisfactory for storing sweet potatoes in the South, because it is practically impossible to keep this type of house dry, and moisture in the storage house will cause the crop to rot.

"The foundation of the storage house may be in the form of pillars or solid walls and should be of such a height that the floor is about on the level of the bottom of the wagon bed, while the footings should be carried below the frost line or to solid ground. Girders 6 by 10 or 8 by 8 inches in size are usually placed on pillars.

"Where cement, brick or stone foundation walls are built, they should extend 18 to 20 inches above the ground level; and plates 2 to 3 inches thick and 8 to 10 inches wide should be placed on the wall. In using walls for the foundation it is necessary to provide means for ventilation under the house. This can be done by placing small windows in the foundation every 10 to 12 feet. Even where solid outside foundation walls are used it is advisable to use pillars for the center supports.

"The principles of constructing storage houses of various sizes are very much the same; therefore, only one, the 12 by 16 foot house, will be described (see Fig. 26).

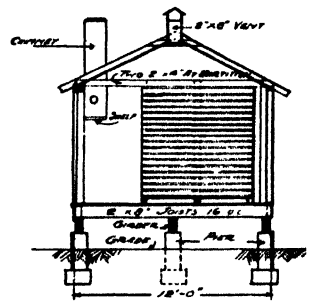

FIGURE 26.—Cross-section of a small sweet potato storage-house (12 x 16 feet).

"For this small storage house, having a capacity of 400 to 500 bushels, build three rows of pillars, one row under each side and one under the center of the house. Girders 6 by 10 inches in size are placed on the pillars and on these 2 by 8 inch joists,

spaced 12 inches apart from center to center. The walls of the storage house are made by setting 2 by 4 inch studs on the girders every two feet and nailing them to the sleepers. On the outside of the studs 1 by 6 inch boards are nailed diagonally to brace the wall; over these a layer of heavy building paper is tacked and matched siding then put on. A layer of 1 by 6 inch boards is nailed on the inside of the studding, then a layer of building paper, and over this matched boards. In the lower South, the first layer of boards on the inside of the studding may be omitted so far as the control of temperature is concerned, but in regions of high humidity (near the seacoast) it is deemed advisable to use four layers of boards, two on the inside and two on the outside of the frame, as suggested above. The tighter the walls, the less difficulty will be encountered in controlling both temperature and moisture. Two 2 by 4 inch pieces should be placed on top of the studding for eave plates, to which the rafters are nailed. The floor is made by laying 1 by 6 inch sheathing over the joists, then a layer of heavy building paper and over this 1 by 4 inch tongue-and-groove flooring. The building may be covered with shingles, roofing paper, galvanized iron, or any other kind of roofing material; but galvanized iron is to be preferred, because it is durable and lessens danger from fire. Use 2 by 4 inch scantling for rafters and make the roof tight to keep out the cold. The rafters should be cut to fit over the plate at the lower end and to fit snugly against the ridgepole at the upper end. On the outside of the rafters put a layer of 1 by 6 inch sheathing, and over this the roofing material. On the inside of the rafters nail a layer of 1 by 6 inch sheathing, then a layer of heavy building paper, and over this

a layer of tongue-and-groove ceiling. If desired, joists may be placed across the building on top of the eave plates, and the sheathing, paper, and tongue-and-groove material nailed to the under side of them instead of to the rafters. These joists, if securely nailed to the plate, will serve for tying the sides of the building together, as well as for carrying the insulated ceiling. In a large house this method of ceiling is very satisfactory, as it gives loft space above the storage room and requires less ceiling material.

" The sides of the building should be tied together, to prevent spreading. This can be done by nailing 2 by 4 inch pieces to the plates or to the lower ends of the rafters. It would be an advantage to have these pieces over the bin supports.

" The space between the walls should be left open, because any material used to keep out the cold will absorb moisture. Many storage houses have been built with sawdust, shavings, or similar material between the walls, but this practice should never be followed. Sawdust will take up moisture and when once wet will never dry out. This moisture will keep the house damp and cause the walls to rot. The air space is a good insulator if the walls are made tight, and they will be tight if the plans given are followed.

" Thorough ventilation is necessary in a storage house. This is provided by means of windows, doors, and ventilators in the floor and through the roof. The openings in the floor around the stove prevent overheating the potatoes near the stove. The bottom of the windows should be within 8 inches or 2 feet of the floor. The windows and doors must be made so as to close tightly to keep out the cold. All windows should be

made to open from the outside, as the bins will interfere with opening them from the inside. Where glass windows are used, outside shutters are put on, and these should be well padded. Some of the windows should be made of glass, so as to admit light without letting in cold air, as it is necessary to have a light when working in the house and in cold weather the house should not be kept open. All of the openings must be made so that they can be closed quickly and tightly whenever necessary. The ventilators in the roof should extend through the ceiling, so as to carry out the warm air as it rises. Ventilators 8 by 8 or 10 by 12 inches, made of wood, are very satisfactory. These should be provided with a roof to keep out rain and at the bottom end with a tight-fitting shutter, which can be closed in cold weather. The ventilators in the floor may be holes 12 by 12 inches, but they should be provided with wire-netting screens and tight-fitting covers that they may be closed when necessary.

"The arrangement of the interior of the house depends upon the methods of storage used. Some growers store the potatoes in boxes, crates, baskets, or hampers, while others store in bins. The smaller containers are to be preferred to bins where it is practicable to use them, because they eliminate considerable handling and reduce the amount of decay. Many growers store in the hampers that are to be used for marketing the potatoes. This is a satisfactory plan, as it requires no outlay of money for storage receptacles, and the packages for shipping must be provided in any event if the crop is to be marketed. Some growers have bushel boxes made for the special purpose of storing sweet

potatoes, while others employ various types of used crates. In using any type of package it is necessary to provide means for ventilation. A false slatted floor is often made by nailing 1 by 4 or 1 by 6 inch boards to 2 by 4 inch scantling. An inch space should be left between the boards to allow the circulation of air. A little space should be left between the stacks of boxes, baskets, crates, or hampers. Where these smaller containers are used, especially when the same package is

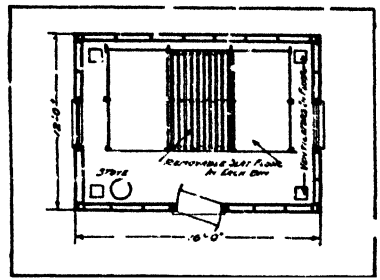

FIGURE 27.— Floor plan of a small sweet potato storage-house (12 x 16 feet) suitable for a farmer who has 300 to 500 bushels of sweet potatoes to store.

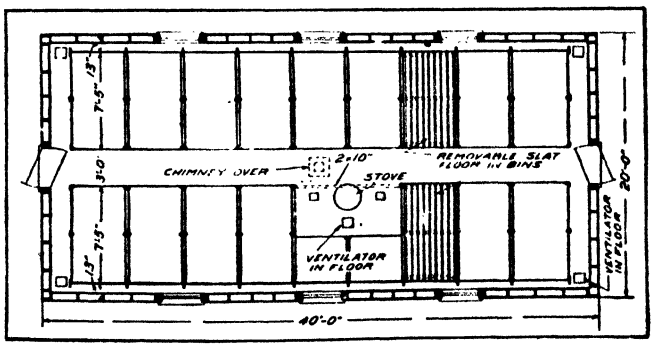

FIGURE 28.— Floor plan of a 20 by 40 foot sweet potato storage-house having a capacity of 2,000 to 2,500 bushels.

employed for shipping the crop, it is much easier to disinfect the storage house by spraying than when bins are used. Another advantage in using them is that when decay sets in it usually spreads only to the potatoes in the single package, whereas in the bin it might spread throughout the entire pile.

" If the bins are to be used, the interior of the storage house should be arranged for convenience in handling sweet potatoes. A passage way about 3½ to 4 feet in width is usually left between the rows of bins, or between the wall and the bins in a house with

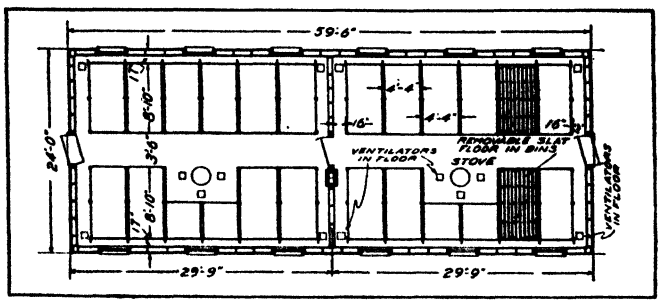

FIGURE 29.— Floor plan of a 24 by 60 foot sweet potato storage-house having a capacity of about 5,200 bushels.

only one row of bins. Sufficient open space must be left to allow access to the ventilators in the corners of the storage rooms. Satisfactory arrangement of passage-ways and bins are shown in the floor plan of Figs. 29 and 30.

" The bins are made as follows: For the corner and middle supports, 2 by 4 inch scantlings are set up, the lower end nailed to the floor and the upper to the crosspieces used for tying the sides together. Over the

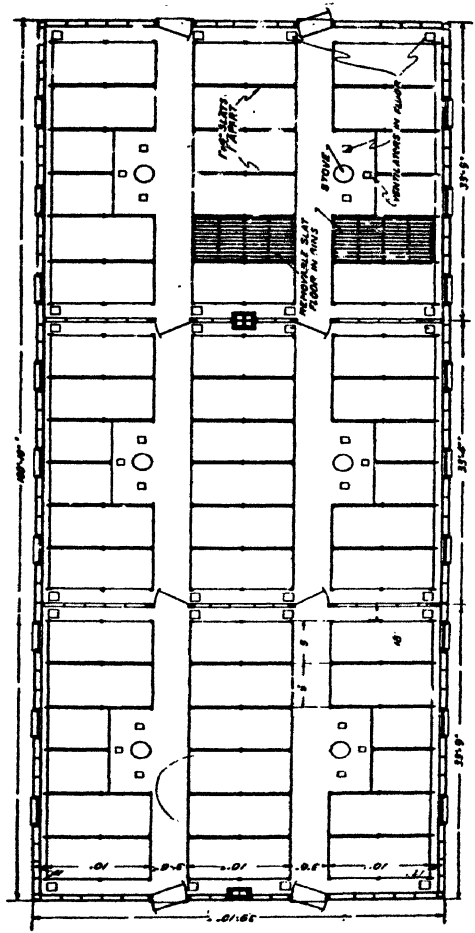

FIGURE 30.—Floor plan of a 40 by 100 foot sweet potato storage-house having a capacity of 15,500 bushels.

supports, 1 by 4 inch boards are nailed, leaving a 1-inch space between them. The ends of the bins parallel with the outside wall of the house must be built first, because there is not room enough to work between the bin and the outside wall. In making the slat false floors, 2 by 4 inch scantlings are cut to go across the bin and placed on edge, one near each end and one in the center. To these 1 by 4 or 1 by 6 inch boards are tacked, leaving a 1-inch space between them. If left loose, the slat floor racks can be taken out when the house is cleaned and disinfected during the summer. The size of the bins will depend somewhat on the arrangement and size of the house, but it is not advisable to make them more than 5 feet wide, 6 to 8 feet deep, and 10 to 12 feet long. There should be a 6 to 12 inch space between the walls and the bins, to allow a circulation of air. It is necessary to slat up both sides of the scantlings between the bins, in order to leave an air space between the potatoes in the different bins. The construction here described allows a 4-inch space under the bins, and 6 inches between the bins and outside wall."

Operation of the storage-house.

Before filling the storage-house each season, all decayed and mummified potatoes and rubbish should be removed, the house thoroughly swept, and then sprayed with some good solution such as corrosive sublimate,. prepared as follows: Corrosive sublimate, 1 part; hydrochloric acid, 2 parts; water, 1000 parts. Corrosive sublimate is very poisonous and should be handled as a poison. It should be mixed in a wooden vessel, as it will very quickly corrode any metal container.

As soon as the house has been thoroughly cleaned and disinfected, a fire should be started in the stove to dry out the room. This fire should be kept going during the entire filling process. This is advisable so as to dry the surface moisture from the potatoes as they are brought in. As soon as the house has been filled, the doors should be closed, but the ventilators, both top and bottom, should be kept open as much as possible and at the same time maintain a temperature of 80°. When air is heated it rises to the top and will pass out through the ventilators. This causes a suction of fresh air at the bottom, which in turn is heated and passes out at the top, thus causing a constant flow of warm dry air through the potatoes. The false floor of the bins being four inches above the regular floor of the house, the walls of the bins being away from the storage-house walls at both sides and back, and the bins being separated from each other with a two-inch space, free circulation of the air is provided throughout the house. This circulation is absolutely essential if sweet potatoes are to be cured properly. A temperature of 80° to 85° during the curing period is preferable, though in certain cases when the potatoes are unusually wet and sappy a higher temperature is necessary. As soon as the potatoes are cured, which can be determined by a characteristic velvety feel and the first appearance of sprouts, the heat should be cut off and the temperature lowered as rapidly as possible to 60° F. or below.

A coal or wood stove is simple to operate and raises the temperature more rapidly; at the same time, it carries all products of combustion to the outside. An oil stove, unless an unusually high grade of kerosene is used, will sometimes give wick trouble when left to

itself for several hours, getting clogged up with impurities in smoke or fumes. It is unnecessary to fire at night, because the air among the potatoes circulates slowly. The air in the open spaces of the room is dry after a day's firing and diffusion of moisture from among the potatoes in the bins or crates keeps the drying process going on through the night. The process may be lengthened slightly in this way, but no damage seems to result. Whenever spots of dampness are seen on the potatoes or on the walls, ceiling, or stove-pipe (when this is cold), some moisture is present which should be driven out. On the other hand, however, the drying process should not be carried too far. Excess drying will show up in shriveling or other symptoms readily noticeable.

Extreme care should be taken to operate the house properly during the entire storage period. The following general rules are given as a guide for this process, which will necessarily have to be supplemented by the judgment of the operator to meet existing conditions in his individual case:

1. Avoid temperature below 40° F. as potatoes are easily injured by cold(proper temperature can be maintained by regulating ventilation at doors, windows, and ventilators). Occasionally in exceedingly cold weather a little fire in the stove may become necessary.

2. Proper ventilation is essential. On bright warm days when the sun is shining, windows, doors, and ventilators may be left open; while in damp rainy weather moisture should be kept out of the house as much as possible by keeping these openings closed.

3. Keep the house dry. If moisture collects on the

ceiling or walls, a fire should be started immediately and sufficient ventilation given to dry the moisture out of the house.

4. Except in unusual cases do not sort potatoes after they have been stored with hopes of stopping the decay, for in so sorting some sound potatoes will be bruised and the diseased spores on the decayed and decaying potatoes will be scattered into the air and carried through this medium to the sound potatoes which have been bruised in resorting. Thus in a few days as many decayed potatoes will be found in the resorted bin as before they were assorted. If potatoes have been properly cured, even though one potato in the center of the bin rots, it is not likely to contaminate the potato next to it.

Outbuildings for storage-houses.

Some of the most successful sweet potato storage-houses are old tenant houses, cribs, or other outbuildings that have been converted at small cost. This practice is very practicable and can often be done with a small outlay of capital. Thus, proper storage facilities are brought in reach of everyone. In remodeling old houses, care should be taken to have the walls double and tight, so as to obtain a dead air space between the walls. The building should be ceiled, the ceiling covered with building paper and receiled with 1 by 4 inch tongue-and-groove ceiling, or flooring. In converting brick, concrete, or stone houses, it will be best to build a tight wooden wall several inches from the masonry wall and then proceed with the bin construction as if the house were wooden throughout. In constructing the

ventilators in a remodeled house, it is sometimes inconvenient to have the bottom ventilators in the floor. In such cases they may be placed in the side of the wall as near the floor as possible. This plan is not as good as having the ventilators in the bottom of the floor, because a wind blowing in the direction of the ventilators is liable to cause a draft on the potatoes, which is not advisable. But if care is taken to operate the ventilators properly, this disadvantage can be offset to a certain extent.

There is nearly always a difference in temperature from top to the bottom of the house. This condition has been found to exist in practically all storage-houses and should be overcome as much as possible by the proper regulation of top and bottom ventilators. Warm air naturally rises to the top and unless care is taken the potatoes are likely to become over-cured at the top and not cured enough at the bottom of the house.

Commercial curing-houses.

It will be noted that the so-called "government" storage-house just described is operated by the natural connection of air currents regulated with vents. The problems met in operating such houses up to 5,000 bushels capacity are well worked out and may be successfully solved by following the directions given, but the very large houses in which the natural connection of air currents is depended on entirely have not always given the desired results. A number of specially designed commercial houses are on the market which are said to provide more satisfactory storage conditions. Most of these are covered by patent and are erected for buyers by the patent owners. Their principal merit

lies in special fanning and ventilating devices which are provided and in the more uniform distribution of heat secured by means of special conduction pipes which may be run to each bin and controlled by dampers. The detail construction and operation of these various patent houses embrace a study too exhaustive and technical to be taken up here. Full descriptions and information covering operation may be secured from the various construction companies.

Banking.

Although the scientifically regulated storage-house already described is now recognized as the only safe way to keep sweet potatoes, it will no doubt be many years before all growers provide themselves with these houses. If potatoes are to be banked (see Fig. 31), the very best methods should be used in order to offset as far as possible the many disadvantages which will be present in spite of all that can be done. Thompson [1] has very ably given the disadvantage of storage in pits and at the same time explained how these

FIGURE 31.— A long pile of potatoes to be covered with straw and dirt. A very poor method of banking potatoes.

[1] Farmers' Bull. 970, pp. 24-5-6.

disadvantages may be overcome partially by the use of scientific methods, as follows:

"The main disadvantages in the pit or bank method of storage are (1) the large amount of loss due to decay; (2) the inferior quality of the sound potatoes, due to lack of proper curing; (3) the loss on the market, because banked potatoes will keep for such a short period after being removed; and (4) the inconvenience of getting the potatoes when needed, especially during cold or rainy weather. If it is impossible to build a storage house the potatoes should be cared for in some other way, and it is much better to store in pits or outdoor cellars than not to store them at all. By using the best methods of banking known, the loss by decay can be materially reduced but not eliminated, because it is impossible to control the moisture and temperature.

"Storage pits should be located where the drainage is good. In making a pit a little of the surface soil is thrown back to form a level bed of the size desired. It is a good plan to dig two small trenches across the bed at right angles to each other, to provide for ventilation at the bottom. Lay boards or place troughs over the trenches, and at the point where the trenches cross set a small box on end to form a flue up through the pile of potatoes. The earth floor of the pit is covered with 4 or 5 inches of straw, hay, leaves, or pine needles, and the potatoes are placed in a conical pile around the flue. A covering of straw, hay, or similar material is put on the pile and over this a layer of soil. The covering of soil should be only a few inches thick, but increased as the weather gets cold. Keep the ends of the trenches and flue open until it is necessary to close them to keep out the frost. It is better

FIGURE 32.— A number of sweet potato banks illustrating the method of ventilation by the use of troughs at the top of each pile.

to make several small pits rather than one large one, because it is best to remove the entire contents when the pit is opened. Fig. 32 shows a number of pits with a trough ventilator placed over the top of each pile of potatoes.

" A type of storage cellar similar to the one shown in Fig. 32 is often used in the South for storing sweet potatoes. This form of storage is much better than

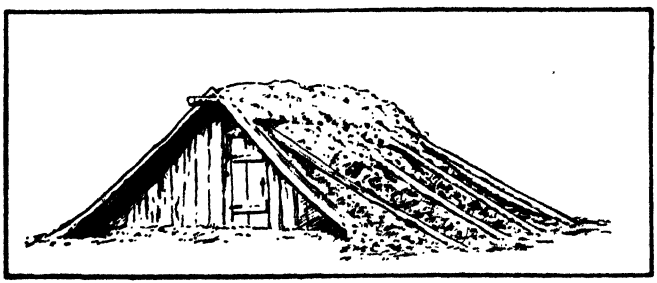

FIGURE 33.— A type of outdoor cellar used in some sections of the South for storing sweet potatoes. The structure should have openings near the bottom and through the top for the purpose of ventilation.

pits of banks. The potatoes can be cured in the outdoor cellar, and it is easier to get them when wanted for the table or for market. A good type of outdoor cellar can be made as follows: Set a line of posts to form the center supports and on these posts put a ridgepole. Against the ridgepole place one end of planks, poles, or slabs, with their opposite ends resting on the ground on either side. The ends of the inclosure are boarded up, a door being provided in one end. The structure is covered with sod to a thickness of 5 or 6 inches. It is a good plan to put a ventilator through the top and to leave two or three openings in the sides near the ground. Provision should be made to close all these openings during cold or wet weather. By placing a small stove in the storage cellar the potatoes can be cured in the way that has been described for the storage house. The potatoes are usually piled on a layer of straw, leaves, or pine needles placed on the ground. A better method is to build a slat floor a few inches from the ground and pile the potatoes on the floor. This floor will allow the circulation of air under the potatoes, which will aid in curing them."

CHAPTER XI

PREPARATION FOR MARKET

THE subject of marketing is one of great magnitude and from a purely theoretical viewpoint is a difficult one to study with accuracy, because of the many new influences which continually arise to change modes of handling and disposal of the crop. Our present day civilization, in all of its industrial and commercial activities, is in a state of rapid progress and the farmer who keeps abreast of times in his marketing methods must avail himself of every opportunuity to become familiar with the demands of his trade and hasten to humor the desires of those who buy his wares. People do not mind paying for what they want. The one great principle of all successful selling, which never changes, is to create a desire for the commodity to be sold.

MARKET REQUIREMENTS

The first step to take in any marketing program is to become thoroughly familiar with the requirements expected of a particular commodity on the market on which it is to be sold. If the southern markets prefer and pay better prices for a sweet juicy potato of the "yam" kind, good business principles would not justify the shipment of the dry mealy variety into these sections. On the other hand, it would be poor judgment to

grow, for example, Porto Ricos for New Jersey or Delaware for this section is noted for varieties of exceedingly different characteristics. Growers often have the mistaken idea that because their neighbors grow one kind of sweet potato, they should plant a different variety to avoid competition. Also, if a particular section has built up a reputation for the production of select sweets on the extra early market of a certain city, it would be well for a newcomer to fall in line with custom until he has at least had time to investigate. If after several seasons his experience would lead him to believe that an extra profit could be made by instituting a change in the period of marketing, he can make the change gradually and be governed in his further actions by the results obtained from his experiments. Often an individual grower can in this way build up a very enviable reputation among a select trade of his personal acquaintances. Such individual efforts are frequently very profitable, but it requires time and diligence to acquire such a grasp on trade. It can be done only after a careful study of what the market wants and faithful work to meet the trade desires in such a satisfactory and dependable manner that one's competitors will gradually be out-stripped. Such successes with sweet potatoes by using methods entirely foreign to local customs are rare.

Varieties.

The question of varieties is largely a local problem, depending on the conditions and requirements of the markets served. Confusion still exists with reference to varieties but a few kinds have become so prominent and well known by continual use and widespread recognition that they may well be consid-

ered standard. These standard varieties, such as Nancy Hall, Porto Rico, Big and Little Stem Jersey, Southern Queen or Hayman, and Tolman variety of Old Spanish, are usually most profitable from a commercial standpoint. If grown at all, the less known kinds should be used at home or sold on local markets. Nothing will so quickly gain for a community a good reputation as exclusive shipment of one variety of potato. Coöperative associations can do much toward standardizing their production by adopting one variety and requiring all shipments made through the association to be of this kind. Even among individuals, it is better to select one good variety and grow that exclusively. A dealer who offers only one variety of plants for sale will attract the attention of many who would not otherwise buy, because of his specialization. By state adoption, through the agencies of coöperative associations or state departments of agriculture, Georgia has adopted the Porto Rico; Mississippi, Nancy Hall; Alabama, Triumph; North Carolina, Big Stem Jersey; and Tennessee, the Nancy Hall. In New Jersey, Delaware, Maryland and Virginia, the Jersey varieties predominate. Many considerations must be taken into account in deciding what variety to grow. The market demands will always decide the question in the end. The northern markets at present give preference to the Jersey type, or mealy kinds, though certain varieties grown in the South are now gaining very rapidly in popularity in the northern, eastern and western cities where heretofore they were hardly known. As an example of this growth in 1915, The Gleason Sweet Potato Association of Tennessee shipped a carload of Nancy Hall sweet potatoes to a commission house in Chicago. The com-

mission merchants were unable to dispose of the potatoes and wired the association that only negroes and dagoes were buying them, and for very low prices. The sales manager went immediately to Chicago and found that the conditions were as represented. The car was finally disposed of at 15 cents a bushel. In spite of this setback, the Association refused to change from the Nancy Hall to the then more popular Jersey potato, but continued its efforts to get them introduced. The following year a Chicago buyer on a search for Jerseys visited the Association and asked them to send him fifty hampers of Nancy Halls. These he distributed to the hotels, to the better-class families and to the residences of the city without charge, merely to introduce them. The following week he wired for one hundred additional hampers and these sold very quickly. During the remainder of the season, twenty carloads of Nancy Hall potatoes were sold in Chicago. In 1917 Chicago bought forty carloads of Tennessee Nancy Halls and in 1918 nearly one hundred cars of the same variety from this Association. Efforts are now being made all over the South to build up a stronger trade in the northern and western markets for southern "yam" varieties, and progress has been made.

Selling period.

New Jersey and Delaware growers have built their reputation on the production of a select high quality potato on the extra early market of the North. Fancy prices are received for this early crop which is selected with the greatest care. Although it is expensive to cater to these early market requirements, the growers find it largely profitable. Alabama growers are endeav-

oring to do the same thing with their early Triumph.

After the fancy prices of the early crop are lowered by the regular harvest, many growers prefer to store their crop and wait for better prices. This storage business has been highly developed in certain districts, the storage-house owners buying thousands of bushels and keeping until the bulk of the crop has been marketed and prices again go up. In some sections the operation of these storage plants is financed by the local banks, and in such cases no difficulty has been experienced in getting their warehouse receipts rediscounted by the Federal Reserve Banks. Whether or not storage for higher prices will pay depends entirely on the loss from rot, the shrinkage and increased expense of handling, as against the increased price received the following spring. Individual and local conditions will largely be the influencing factors.

Sweet potatoes on the extra early and on the mid-winter and spring markets always bring better prices than when marketed in the fall. During the season 1918–19, the Onley, Virginia, market opened on August 19 at $6.50 to $7.00 a bushel. The highest price reached at all during the season was $7.00 on August 26. On this same market barrels were quoted on October 7 at $3.75 to $3.65.[1] In the spring of the same season, April 12, 1919, these same New Jersey and Delaware potatoes were quoted on the New York market at $3.50 to $4.00 a bushel hamper,[2] which calculated on the basis of net weight was equal to about three times the lowest quoted price the fall before. The 1918–19 shipping season was unusual in market advances. The

[1] Bur. Markets, Market Rep. Sheet, May 6, 1919.
[2] Bur. Markets, Market Rep. Sheet, April 12, 1919.

difference between fall and spring prices is always considerable and is worthy of calculation in determining the best season in which to market.

If the grower caters to the extra early market, the earliest varieties should be grown. In the South, possibly the Nancy Halls and Triumphs will come earliest. The first mentioned also makes a good potato for the middle and late market, but the latter is seriously discriminated against as soon as the yellow varieties come in. Proper fertilization is also a material aid to the early crop.

If the bulk of the crop is to be marketed at digging time to local canning factories, yellow varieties must be grown, but no special attention need be paid to early strains or special fertilization for early production.

When the crop is to be marketed during the spring months after storing, special care must be used to provide adequate and efficient storage facilities and to avoid loss from decay by improper handling and unscientific manipulation of the storage-house. The time of selling, whether on the early, middle, or late markets, will vitally influence all other operations of production and must necessarily be considered in devising an efficient marketing system.

Containers.

The Bureau of Markets, United States Department of Agriculture, as well as many coöperative associations and private dealers, have given considerable thought to the subject of a suitable container for the sweet potato which could be made standard and used universally. Definite headway has been difficult because: (1) the legal weight of a bushel of sweet potatoes varies widely

in the different states, (see Table XIII); (2) the weight of a measured bushel of sweet potatoes (2150 cubic inches) will vary 10 to 18 pounds from fall to spring (especially when kiln dried); (3) a measured bushel of sweet potatoes will vary several pounds in weight according to the size of the tubers and subsequent closeness with which they are packed; (4) a measured bushel of sweets (even of the same size and at the same season) will vary in weight according to the rainfall during the late growing period and the consequent sappiness of the roots; and (5) a number of different containers are at present in use in various parts of the country and each section seems to favor the package which it has adopted by custom.

TABLE XIII.—LEGAL WEIGHT OF A BUSHEL OF SWEET POTATOES BY STATES.

STATE	Legal Weight
Alabama, Georgia, Kentucky, Minnesota, Oklahoma and Texas	55
Florida, Michigan, Missouri, and Virginia	56
Maryland	60
Connecticut, Maine, Massachusetts, Mississippi, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and Wisconsin	54
Arkansas, Idaho, Illinois, Indiana, Iowa, Kansas, Nebraska, Nevada, New Mexico, Ohio, Tennessee, South Carolina, and West Virginia	50
North Dakota and South Dakota	46

Packages versus bulk.— Sweet potatoes were formerly sold and shipped extensively in bulk but this practice is no longer permissible even for short hauls, except

when the roots are to be used immediately for canning. Even in this case, proper ventilation must be provided. Shipping in bulk almost necessitates rough handling, which bruises the potatoes and causes them to decay very rapidly. When shipped long distances, bulk potatoes, even when the car is provided with a false bottom and false walls at the ends, are difficult to ventilate properly and are liable to heat en route, causing disastrous losses.

Sacks.— Handling sweet potatoes in burlap sacks is almost as bad as loading in bulk. It permits the outside roots to become bruised, allows the potatoes to rub together, thus giving entrance for decay organisms, and sacked sweets are difficult to load tight in a car and at the same time ventilate thoroughly. Notwithstanding these disadvantages, several of the southern markets give preference to the bag. New Orleans commissionmen will hardly handle sweets in any container but the 90-pound burlap sack. The Memphis, Tennessee, market at times also favors this size and type containers. When market demands justify the use of sacks, they should be handled with utmost care to prevent bruising and should be properly loaded to insure safe delivery (see page 235).

Requirements of sweet potato containers.— Several factors must be considered in the selection of a sweet potato container. Custom has established some packages as standard and it is usually bad business to go too much against well established customs. Nevertheless, certain facts must be borne in mind if the container problem is to be solved satisfactorily. The present tendency is to use gift packages exclusively. Such containers go with the potatoes and must be considered as one of the costs of marketing. Such containers as

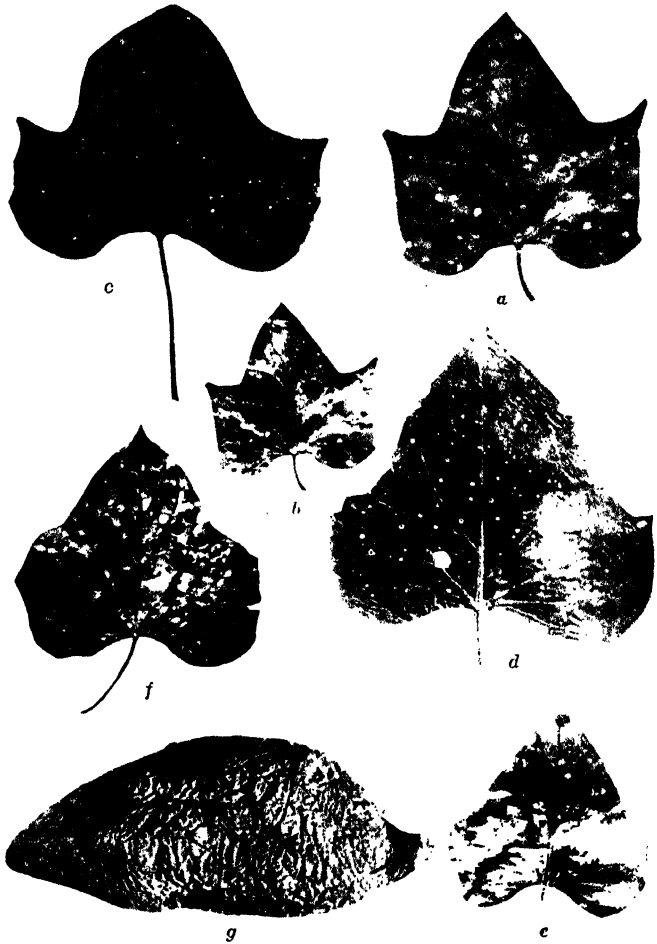

PLATE VIII.— Sweet potato diseases. *a* and *b*, Leaf of sweet potato plant, showing the presence of a number of circular leaf-blight spots. *c* and *d*, Leaf of a sweet potato plant, showing white spots caused by the leaf-spot fungus. *e* and *f*, Leaf of a sweet potato plant, showing the white-rust fungus. *g*, A sweet potato showing the characteristic appearance of dry-rot.

hampers, baskets, bushel crates and barrels are customarily used as gift packages. Occasionally a grower can collect his baskets or hampers from local buyers if the goods are sold with that understanding, but they are ordinarily used only once, the original cost being an important item. In addition to being cheap, the containers should be attractive as well. Nothing helps to sell a bushel of sweet potatoes more than a neat attractive package. The package should be convenient to fill, seal, and handle. One of the most important items is to have a package that can be packed tightly in a car to prevent shifting, and at the same time provide ample ventilation. The containers should be light in weight to economize in freight, express and handling charges, and strong and durable to prevent breakage in transit.

Kinds of packages.— Sweet potatoes are usually shipped in 160-pound barrels, ⅞- and 1-bushel hampers, or in 1-bushel crates. Barrels are most extensively employed on the Atlantic Coast, while crates, which are just coming into prominence, are used almost exclusively in the South. Hampers are utilized in the southern, northern and western sections. Although at present one of the most popular containers, it has never given satisfaction because it is too light to be durable.

Barrels.— Growers of the eastern states have used barrels for many years. They are, however, practically unknown in the western areas. The single-headed cloth top barrel appears to be the most satisfactory one now in use. When properly made and loaded, they are sufficiently strong to carry the weight of the contents and fully protect the potatoes (see Fig. 34). Slat, or veneer barrels are too flimsy for sweet potatoes; they crush or break easily and should not be used for any

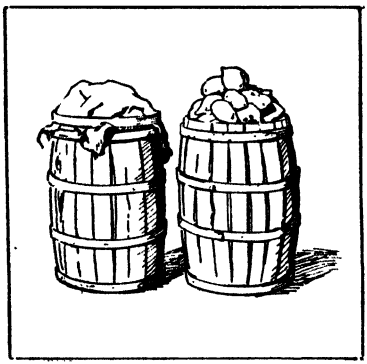

FIGURE 34.— Barrel pack commonly used for shipping sweet potatoes from Norfolk, Virginia.

heavy produce. Many barrels are still set up in the factory and shipped or hauled to the place where used. This, of course, requires a considerable outlay for freight or drayage, as nearly as many full barrels can be hauled as empty ones. In this respect folding crates or baskets that can be produced in telescope fashion have an important advantage over the barrel. As it requires a comparatively large outlay of cash to equip a shop for setting up standard barrels, a number of cooper shops have been established throughout the east central sweet potato growing area. Due to the increased scarcity of board and the high cost of labor, recent prices have been almost prohibitive and even in the Atlantic Coast sections, other containers are gradually replacing the barrel. A standard sweet potato barrel should have the following specifications:

	inches
Length of stave	28½
Diameter of heads	17⅛
Diameter between heads	26
Circumference of bulge (outside measurements)	64
Thickness of staves, not greater than	4/10

"Provided that any barrel of a different form having a

capacity of seven thousand and fifty-six cubic inches shall be a standard barrel." [1]

Hampers.— Although veneer hampers are too light for sweet potatoes, their attractive appearance and convenience of handling have made them a very popular container on the big markets. However, the shipper will have to count on occasional severe losses from breakage

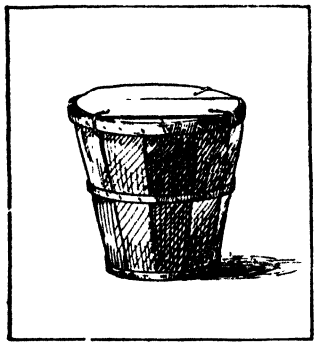

FIGURE 35.— Seven-eighths bushel hamper, 16 inches high, one of the most popular containers for marketing sweet potatoes.

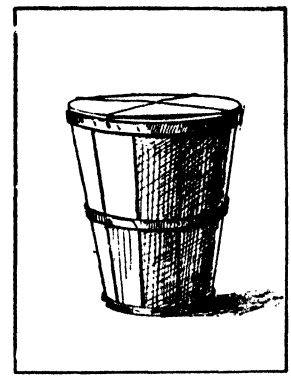

FIGURE 36.— Full bushel hamper, 18½ inches high.

in transit, even with the most careful packing. If market demands and convenience justify the use of hampers, they should be loaded on end with alternate baskets inverted and packed with the greatest care (see page 236). Two sizes are used: the ⅞-bushel and the full bushel hamper. Manufacturers usually make the full bushel hamper 18½ inches high with a capacity of about 2150 cubic inches. They are made of light hardwood veneering, fastened together with wire staples

[1] Farmers' Bull. 1050, p. 18.

and furnished with covers fastened with wire. The ⅞-bushel hamper is a duplicate of the full bushel except in height and the manner in which the top is fastened, hooks being used instead of wire. The ⅞ lacks 2½ inches of being as tall as the full bushel size. (Figs. 35, 36).

Crates.— Marketing specialists who have long been seeking a satisfactory solution to the container problem for sweet potatoes have looked with expectancy to the crate in one form or another to answer the question. A rectangular crate when properly made is attractive, is easily ventilated, is convenient to handle, packs well in a car, and can be made strong enough to hold up without breakage. The convenient lumber supplies and the manufacturing facilities of the southern states also make the crate a very economical package to use. The crate can be shipped folded or knocked down and is, therefore, economical of transportation charges. Growers can often make their own crates economically when suitable material is convenient. The objection to the crate at the present time is that it is now little known in the principal markets, and sometimes does not bring the prices commanded on the same market by a better known container. This objection is, however, being very rapidly overcome by its introduction on the big markets by the southern states and shipping associations. During the season of 1917–18 and 1918–19, Georgia established a reputation on the world markets with her "kiln-dried Georgia Porto Ricos in 50 pound crates." Without doubt this package is destined to become very popular and widely used in the near future. At a meeting of shippers, growers and carriers held in Jacksonville,

Florida, on August 14–15, 1913, standard containers were adopted for a number of commodities, including a standard crate for sweet potatoes. As this package was recommended by the Bureau of Markets, United States Department of Agriculture, and is representative of the general type of rectangular crate now on the market, the following specifications are given:

"Specifications of Standard Crate.

Dimensions: $12 \times 12 \times 15$ inches inside measurement.

Capacity: 2160 cubic inches.

Heads: Two heads, solid (12×12 inches), not less than $^{13}/_{16}$ inch thick, made in one or two pieces stapled together, or panel heads made of head sticks not less than $^{13}/_{16}$ inches thick and $1\frac{1}{4}$ inches wide.

Panels: Two end panels made of one piece not less than $^{3}/_{16}$ inches thick, securely nailed to head sticks with not less than 4 No. 16 gauge $\frac{7}{8}$ inch wire nails, top and bottom, and not less than 3 No. 16 gauge $\frac{7}{8}$ inch wire nails across the sides (total ten nails). The veneer may be stapled with 8 double pointed staples $\frac{7}{8}$ inch long made from No. 18 gauge wire.

Slats (Top, sides and bottom): Twelve slats, three each on top, bottom and sides, not less than $3\frac{1}{2}$ inches wide, $\frac{1}{4}$ inch thick and 17 inches long, stapled together with cross cleats at each end, each $^{3}/_{16}$ inches thick and $1\frac{1}{2}$ inches wide, using No. 20 gauge wire.

Making up: Top, sides and bottom must be securely nailed with not less than six cement coated 4d nails in each end, two in each slat.

Wood: Veneer or sawed. To be of seasoned pine or gum or wood of equal strength, free from injurious knots.

NOTE: When sweet potatoes are shipped in this crate, the slats must be 3 inches wide."

Various other crates are on the market which industrial manufacturers and growers claim to have special merit. Figs. 37 and 38 show a type of folding crate

which is very popular. The ends and sides are fastened together with strong wire hinges, and when the bottom is dropped into position and the top put on, the box is rigid and durable. The boxes are shipped folded flat. In setting up the boxes, no nails, tacks, or metal fasteners of any kind are used. It is only necessary to place the narrow strip under the hinges at one end of the box to fasten the top securely. This type of box, of which there are several brands on the market, is patented and usually costs a little more than the ordinary standard shipping crate. Fig. 39 shows an octagonal shaped crate which is sometimes made at home and used for shipping sweets. It is, however, little known on the markets, and only in special cases where lumber is cheap would it be profitable. By reference to Table XIII it will be seen that it is absolutely impossible to make a crate that will hold a bushel of po-

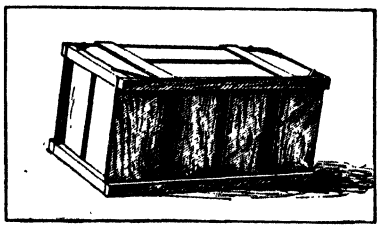

FIGURE 37.— Universal folding box, a very substantial patented crate.

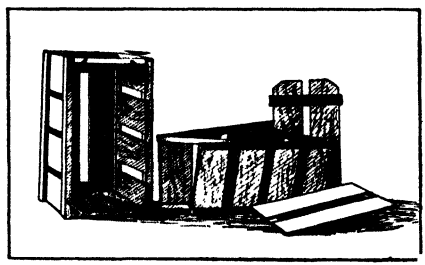

FIGURE 38.— Showing universal folding crate before bottom is placed and standing on end after placing bottom in position.

tatoes by weight. The Bureau of Markets favors the establishment of a standard bushel crate by volume to the one adopted by the Jacksonville meeting in 1918. If this crate is rather small, one containing one-half bushel by volume could also be used. On some of the markets, such as Denver, Colorado, 100-pound crates are sometimes seen, but in the eastern markets barrels are commonly employed when a container is desired holding more than one bushel. More standardization of the containers in shipping sweet potatoes is needed, and such standardization can only be brought about on a volume basis.

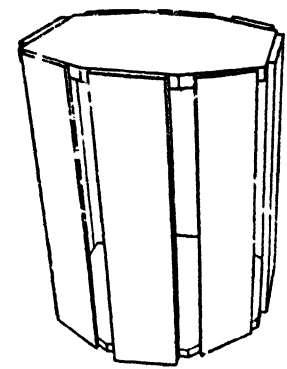

FIGURE 39.—Octagonal shipping crate for sweet potatoes.

PROPER PRODUCTION

When the individual has determined to his own satisfaction the best varieties or variety to grow, the season of the year in which the potatoes will net the biggest return and the kind of container which seems best suited to his individual needs, he has found out the actual requirements of his market. In other words, he has discovered the technique of the marketing business. Marketing really begins with production. Unless the producer can put into his stock the desirable quality; unless he grows a quantity sufficient to enable him efficiently to utilize his labor and equipment, and to supply his market demands; unless his potatoes are properly

harvested, handled to prevent bruising, and graded or culled according to trade requirements, he has not solved his marketing problems. The grower must know how to produce the finished article in the most profitable manner possible if he is to reap the rewards of a well-rounded marketing system.

Quality.

All trade admires superior quality. The actual "velvet" received on a transaction involving a large shipment of sweet potatoes is often realized entirely on the degree of superiority which the shipment in question possesses over the average market quality. Quality includes every factor which makes the goods more attractive and desirable because of uniformity, grade, or edible characteristics. The Eastern Shore of Virginia Produce Exchange has built up for itself a very enviable reputation for the quality of its "Star Brand" Irish potatoes, and this same Association is doing much for the sweet potato industry in that section. Individuals and coöperative associations need to set for themselves a certain standard of excellence and always live up to this standard. This is the only way to gain a reputation for honesty, fair dealing and superior quality. Many of the New Jersey and Delaware growers take great pride in cultivating this special fancy trade, and the same may be said of individuals throughout the South and Central West.

The quality of a sweet potato is materially influenced by the type of soil on which it is grown, the rainfall, the variety, fertilization, cultivation, harvesting, curing, subsequent handling and grading. All of these sub-

jects have been fully discussed in other parts of this work except the handling and grading, which will be treated in the following pages.

Grading. (See Fig. 40.)

The sweet potato root which brings the highest price on the markets is of medium size, smooth and uniform and spindle-shaped, that is, long, and tapering from the middle towards both ends. The roots of varieties should never be mixed. For all practical purposes the average farmer will use only two grades roughly classed, (1) those to be marketed, and (2) those used at home. When sold to a canning factory, the potatoes are usually taken "field run" and do not require grading. Sweet potatoes for the general market should not be less than 1½ nor more than 4 inches in diameter, and not more than 7 inches long. The following grades on sweet potatoes which were temporarily adopted by the State Department at Austin, Texas, August 16, 1918, have furnished the basis of all attempts for standard grades made since that time:

"No. 1. This grade shall consist of sound sweet potatoes of similar varietal characteristics which are practically free from dirt or other foreign matter, frost-injury, bruises, cuts, scars, cracks and damage caused by diseases, insects or mechanical means. The diameter shall not be less than one and three-fourths inches nor more than three and one-half inches.

"Five percentum by weight of any lot may be below the least or above the greatest diameter prescribed, and, in addition, five percentum by weight of such lot may be below the remaining requirements of the grade.

"No. 2. This grade shall consist of sound sweet potatoes of similar varietal characteristics not meeting all the requirements of grade No. 1 which are free from serious damage caused by dirt or other foreign matter, frost-injury, heat decay, bruises, cuts, scars, dry rot or other diseases, insects (including weevils) or mechanical means. The diameter shall not be less than one and one-half inches.

"Five percentum by weight of any lot may be less than the diameter prescribed, and in addition, five percentum by weight of such lot may be below the remaining requirements of this grade.

"'Sweet Potatoes' include yams.

"'Practically free' means that the appearance shall not be injured to an extent readily apparent upon casual examination of the lot and that any damage from the causes mentioned can be removed by the ordinary processes of paring without appreciable increase in waste over that which would occur if the sweet potatoes were perfect.

"'Diameter' means the greatest dimension at right angles to any portion of a central line running through the sweet potato from stem end to root end.

"'Free from serious damage' means that the appearance shall not be injured to the extent of more than 20 percentum of the surface, and that any damage from the causes mentioned can be removed by the ordinary process of paring without increase in waste of more than ten percentum by weight over that which would occur if the sweet potato were perfect."

A number of attempts have been made to design a practical sweet potato grader, but thus far all efforts

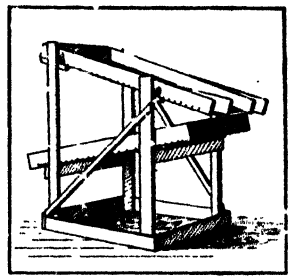

FIGURE 40.— An easily constructed potato grader.

have been futile and the best means of grading now known is with the hands. A mechanical grader is rendered difficult of design because of the oblong rather than round shape of the sweet potato, and the ease with which these roots are bruised by handling. The construction of a rather ingenious grader to be operated by means of a sieve of braided belts was at one time undertaken by an employee of the United States Bureau of Markets, but for some reason was never completed.

Quantity.

A consideration which must enter into the calculations in formulating a well-balanced marketing system through the production end is the question of quantity. A farmer should never grow more potatoes than he can efficiently handle or his available market will absorb. At the same time, he must grow enough to supply his profitable trade and keep his labor, team and capital busy in such a way that the cost of providing a bushel will be reduced to a minimum. If all of the potatoes are to be marketed when dug, the amount to grow will depend almost entirely on the harvesting period, the absorption power of the market at that time, and the labor which will be available when harvest time arrives. If adequate storage facilities are available, the potatoes can be handled much faster, in greater quantities and

with less danger of loss from growing more than can be marketed immediately than when such facilities are absent. The distance to the railroad, the possibility of securing coöperation from neighbors, available team, condition of the roads, distance from loading point to destination and expense will all be vitally influencing items in properly regulating the quantity production side of the business.

Storage.

Inasmuch as storage often enables one to receive double the price for sweet potatoes, it constitutes a very important phase of profitable marketing. It is also common knowledge that well-cured sweets are superior in eating quality to those which are not kiln-dried. The buying public recognizes this fact and such stock is given preference by the big markets.

Storage-houses often render handling more economical and profitable because of the ease with which potatoes may be placed in storage and then packed and shipped out at some later date when farm labor is not so much needed in routine crop harvesting operations.

PACKING OPERATIONS

The proper time to grade sweet potatoes is in the field at digging time. If to be kiln-dried, grading may be facilitated by storing in crates which may be taken directly to the field and the various grades placed in separate crates and hauled to storage without further handling. Even when handled in this way, the potatoes should be resorted before shipping out the following winter or spring. This should be done by placing the roots directly into the containers in which they are

shipped, as they are taken from the storage crates. Every care must be used to prevent bruising in all handling operations, as such blemishes give an opportunity for bread mold, or soft-rot to set in. Containers must be chosen for their carrying quality and economy in the sense of properly protecting the potatoes from injury.

FIGURE 41.—Sweet potato barrels and device for pressing the heads into place.

In packing barrels, no especial care in filling is necessary as in the case of apples or other fruit, but the rocking should be done about three times during the process of filling to insure a good pack and full measure (Fig. 41). As the process of filling progresses, the barrel is gently rocked back and forth to settle the roots well down as closely together as possible. This process is started by placing the barrel on a plank about two inches less in width than the diameter of the barrel, instead of using a follower to hold down the potatoes and inserting a head, or as is sometimes done with Irish potatoes and frequently in packing various fruits, the barrel is slightly hooped, or as is known in fruit-packing bilged. The burlap cover is usually secured by having it covered by the top loop. If the barrel has been properly packed and rocked, 1 to 1½ inches bilge will insure a full barrel on arrival at destination. If the bilge is too much, the top layer of potatoes will be so badly bruised in transit that they will decay rapidly when opened.

Growers who are working up fancy trade sometimes use paper lining around the inside of the barrel, with corrugated paper caps on the ends. These caps are supposed to prevent bruising. Lace circles of paper are often placed on top to make the barrel more attractive when exposed for sale. These frills are, however, uncalled for and with sweet potatoes more than any other farm crop superb quality of the product with neat and substantial packing will in the end prove most profitable.

In packing hampers or crates, there is less temptation to bruise the potatoes by dropping into the containers than is true of barrels. Sweet potatoes should be lifted from one container and placed as carefully in another as in handling eggs. It is remarkable the speed that can be acquired with a little practice and at the same time handle the roots in such a manner that they will not be bruised. Hampers or bushel crates should be packed tightly with about ¾-inch bilge. A full bushel hamper or crate holding 2150 cubic inches will hold 50 to 52 pounds of No. 1 sweet potatoes after they have been cured, if tightly packed. Most growers try to put 51 pounds into a package of this kind, calculating that it will contain about 50 pounds net when it reaches the consumer. The appearance of packs can be greatly enhanced if careful facing is done. By facing is meant the special placing of the top layer of potatoes to insure a smooth, even and attractive surface. Facing is not a means of defrauding the buyer by placing potatoes of one grade on top and inferior grades on the bottom and selling the whole on the basis of the top quality, but consists in the systematic arrangement of the top layer of potatoes so that the appearance will be pleasing. Proper facing not only assists in

selling but prevents undue bruising of potatoes that might otherwise be projecting above the average level of the pack.

Crates or hampers which hold a bushel are quite convenient to handle and make attractive packages. The objection sometimes heard to the crate is that if there is a small or off-grade potato in the package it will be more readily seen than with the hamper. This is no doubt true but should not be a serious objection, as it enables the buyer to see exactly what he is getting and encourages the strictest honesty and careful grading on the part of the shipper. The very defect provides an advantage in giving better ventilation.

PROPER TRANSIT

After the requirements of the market have been carefully determined and after all the attendant troubles of production have been effectually overcome, the potatoes safely stored until the prices are attractive, and then perfectly packed in the most secure and attractive manner possible, the business will be a failure if the product is not gotten to market in salable form. The difference between profit and loss is often incurred in forty-eight hours from injuries in transit that have been avoided for months on the farm and in the storage-house. Often these injuries represent losses that could have been avoided had proper attention been paid to: (1) selecting the type of car best suited for the shipment at season in which it was made and for the specific distance which the car was to cover before reaching destination; (2) correctly packing the car with the special containers used; (3) proper regulation of ventilators in transit. The goods must reach the

consumer in usable condition if profit is to result. Even when goods are sold f. o. b. the track, the seller owes it to his customer to take every possible precaution to insure him a safe delivery. Sweet potatoes are extremely perishable and intelligence is essential in providing proper accommodations in transit. Furthermore, the way in which a car is packed has much to do with the commission merchants' possibility of disposing of it profitably at the other end of the line.

Choice of car.

Four types of freight cars may be used for shipping sweet potatoes to market: (1) the common freight car; (2) the air-ventilated cars; (3) the refrigerator cars; and (4) the heated cars.

The common freight cars are the ones in which ordinary merchandise is usually shipped. This type is not well adapted to the shipment of sweet potatoes even for short hauls. They are employed only when a few crates or barrels are shipped along with other merchandise on short freight hauls that can be made in one or two days. Occasionally the common freight is provided with a false bottom and used for shipping sweets to canning factories in bulk, but even in such cases the air-ventilated cars are preferable. Such cars should never be used for shipping car-lot potatoes over long distances, for they are provided with no means of regulating ventilation, and in long hauls, especially with new potatoes, heating is almost sure to occur with disastrous results.

Air-ventilated cars represent the type best suited for handling sweet potatoes in all regions where special insulation is not necessary to prevent freezing. Such cars

can usually be secured as easily as an unventilated box-car, and they should always be used in preference. These cars are provided with two ventilators at either end wall which can be opened or closed as desired. These vent openings have iron rods or heavy iron cloth to prevent stealing when the doors are open. Though not regularly furnished with a false bottom, such a floor should always be installed when shipping long distances and for short shipments when the potatoes are bulked. A false bottom can be constructed of rough lumber for about 1 cent a bushel capacity of the car, and is very cheap insurance. In installing such false floors, care should be taken to have the runners placed lengthwise the car with floor strips crossways, and to see that the under air passage formed is not obstructed in any manner, else the object of the false floor will be defeated (see Fig. 42).

The railroads will supply refrigerator cars for perishable or semi-perishable shipments to the extent of their ability, preferably for longer runs. These cars should always be used in shipping sweet potatoes to the northern markets, as the special insulation prevents freezing and the top ventilators in each end provide ample circluation of air as long as the car is in motion. A certain percentage of these cars belonging to the various roads is already equipped with false floors, or floor racks. It is contemplated eventually to equip all of the cars in this way. When not so equipped when secured, the shipper will always find it profitable to put in these floors at his own expense rather than ship long distances with the bottom ventilation that would be provided. During the war period, the United

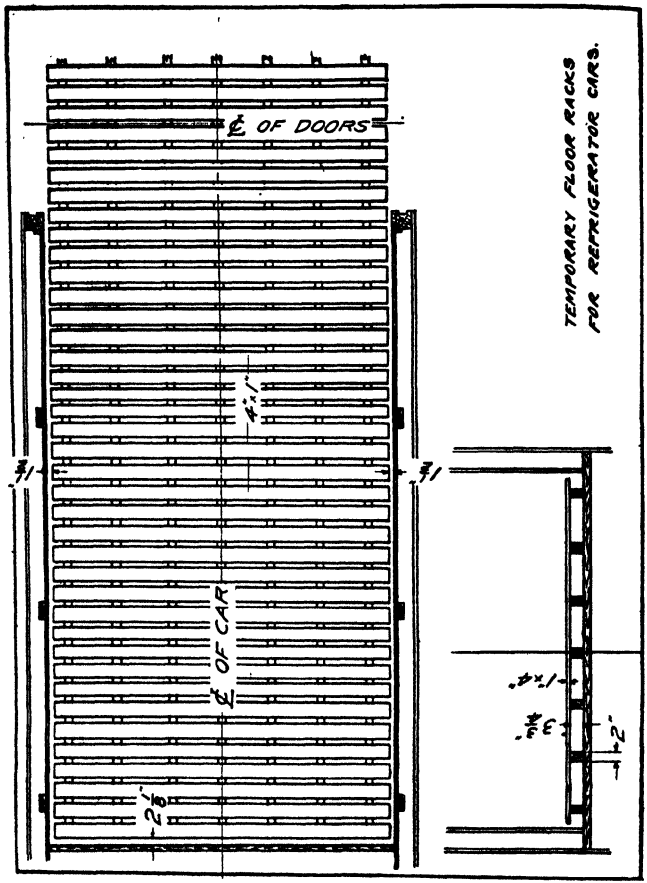

FIGURE 42.— Temporary floor racks for refrigerator cars.

States Railroad Administration issued an order in which they stated that " The railroads will reimburse shippers for the value of floor racks so placed to the amount of

fifty (50) cents per linear foot of the total "inside length of car"[1] but in normal times the shippers would have to bear this expense. No ice is used in refrigerator cars for sweet potatoes. An average of about 630 hampers can be put in a car, 30,000 pounds being considered a safe load. Thorough ventilation is an absolute essential in making successful shipments of sweet potatoes in any type car.

Stock cars are occasionally used for short shipments in warm regions.

Packing in car.

There is an unwarranted tendency toward carelessness in loading sweet potatoes. Often avoidable breakage occurs in cars carefully packed. In addition to ample ventilation, the car should be so loaded as to avoid shifting of the load in transit and breakage of the containers by contact with each other.

FIGURE 43.—A variation of the standard load. Loading 100-pound sacks so as to secure a heavy-weight shipment with the greatest amount of ventilation.

Barrels.— Both the double-headed ventilated barrel and the cloth-top barrel should be loaded on end rather than on their bilge, as investigation shows that much less breakage results.[2] The main objection to loading on end is that when very tightly packed, owing to jolting

[1] Circ. CS-43, U. S. R. R. Adm., W. G. McAdoo, Nov. 15, 1918.
[2] Farmers' Bull. No. 1050, p. 9.

in transit, the barrels may appear to be of slack measure when they arrive at the market. This fault can be largely eliminated by proper rocking of the barrel while filling (page 227). When circumstances justify loading on the bilge, headlines should be used. When loaded on end, five barrels placed across the end of the car will give a snug fit. A 36-foot car will carry 105 barrels in each such layer. When the first layer has been distributed throughout the car, strips of wood should be put on top of these barrels and the second

FIGURE 44.— Barrels loaded on their bilge crosswise of the car. Note that the barrels on the fourth layer should have been against the wall on the right.

FIGURE 45.— Double-headed ventilated barrels loaded on end. Strips should have been placed between the layers in this load.

layer placed directly on top of the first row, taking care throughout the car to keep the barrels tight against each

other. With cloth-top barrels, less bruising will perhaps result if the top layer is loaded on bilge. When loaded in this manner the cloth-tops should be placed toward the inside, particularly in the doorway. In old-sized cars it is sometimes necessary to load all barrels on bilge which are in the doorway to insure a tight fit. In all cases the doorways should be stripped up with lumber an inch or more thick, from the inside to prevent bilging of the doors or falling out of doorways (see Figs. 43–45).

FIGURE 46.— Sacked sweet potatoes being shipped in stock car. Plenty of ventilation, but dangerous on account of changes in temperature.

Sacks.— As stated, sacks are unsatisfactory as containers but are still sometimes used. Sacks holding more than 100 pounds should never be tolerated, 90-pound bags being most commonly used. Loading sacks in any car without provision for ventilation throughout the load is inviting loss. Figs. 46–48 show correct and incorrect ways of loading sacks.

FIGURE 47.— This car was not loaded properly and did not carry safely.

Hampers should never be loaded on their sides. The practice sometimes followed cannot be too severely condemned (Figs. 49–50). Hampers should always be

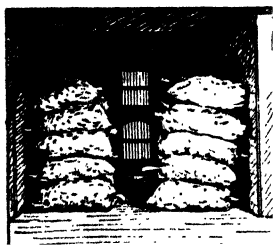

FIGURE 48.— Correct way of loading sacked sweet potatoes.

loaded on end with alternate baskets inverted. Every possible care should be taken to make the load tight with no slack space either at ends or across the car. Some growers prefer to brace the load by nailing strips across the car every three or four tiers of hampers. Frequently no hampers are placed in the door, but each end of the car is braced separately, leaving the door space vacant for ventilation.

Crates may ordinarily be packed tightly in the car

FIGURE 49.— Breakage and damage in a car of hampers loaded on their sides.

and at the same time be sufficiently ventilated by placing strips an inch thick between layers of crates. The crates should be held in place with car strips and no slack space be left under any circumstances without suitable bracing. Especial care is necessary to have the crates securely tight from end to end of the car.

From 300 to 700 crates constitute an average good load.

Temperature in transit.— The effect of various methods of ventilation in transit and the relative influence of varying temperatures on the carrying quality of sweet potatoes are at this time under investigation by specialists of the Bureau of Markets. It is known that ventilation is essential, that overheating is as disastrous, or more so than freezing, and that temperatures between these two extremes may considerably influence the susceptibility of the potatoes to disease attacks and decay. Of the technical details of these things, however, little is yet known.

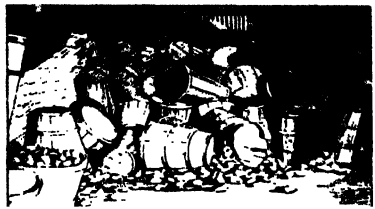

FIGURE 50.— Do your sweet potatoes arrive at market like this?

CHAPTER XII

COMMERCIAL DISPOSAL OF THE SWEET POTATO

THE sweet potato is now going through the process of standardization and introduction into the world markets. This fact will be appreciated when it is noted that out of the eighteen states growing sweet potatoes, those which produce less than one-tenth of the total crop of the United States make more than one-half the total car-lot shipments. Nevertheless, marketing has made remarkable strides within the last few years. It is only in recent years that the general sweet potato grower has taken any interest in the selling of his surplus beyond the limits of his immediate markets. These markets have usually consisted in the many small towns where the potatoes were occasionally peddled out on the streets or in a few local sales in small quantities to neighbors less abundantly supplied.

Conditions have changed very rapidly within recent years and sweet potatoes are now known and called for in many markets which until lately have been in ignorance of this southern delicacy. All regular market reports now quote sweet potatoes in season, along with other leading fruits and vegetables. The standardization of market conditions and the fact that new markets are continually being opened up and old markets are capable of development by controlling seasonal dis-

tribution and carefully catering to the desires of the best trade, make it imperative that the present day grower know something of the available marketing agencies and familiarize himself with the best methods of manipulating his crop through the various chambers of commerce. The present tendency is for the grower to take an active interest in the disposition of his potatoes and in many instances do the actual selling himself. This calls for good business judgment in: (1) choosing the best markets and properly developing them; (2) cultivating sales in various markets; (3) properly weighing the importance of various sales factors which influence market conditions each season; and (4) dealing with the different selling instrumentalities which commerce will always make legitimate and necessary. The grower must also know something of the terms and methods which may be employed in transacting sales, if his operations are to be placed on a business basis.

At the present time, only two channels of trade are opened to the producer. They consist of the "home market" and foreign markets. The latter term is not used to designate markets outside of the United States, but refers to all markets outside of the state where grown. This usually means shipping to the eastern, northern, or middle-western fruit- and vegetable-consuming cities, as New York, Philadelphia, Cincinnati, Chicago or Omaha. At present, local canning factories handle a large part of the home market trade. These canneries are now located in practically every state where sweet potatoes are of any considerable importance, and are playing an important part in consuming much of the crop during the harvest months. Many enthus-

iastically predict the development of an important export trade in sweets as scientific storage-houses become more widely used.

MARKETS

The markets to be patronized will influence to an important extent all of the pre-marketing operations of the grower. The requirements of different markets should be studied and the advantages and disadvantages of each carefully compared. This will necessarily have to be learned largely by experience. Most growers believe with good reason that they can dispose of their crop more satisfactorily in territory within their reach by wagon, provided the quantity is not so great as to flood the market. Many things favor the home market. In practically all parts of the South it has been the main dependence as an outlet and even so has not been over-supplied when marketing was distributed over the entire year rather than a few months at digging time. There is nearly always a scarcity of sweet potatoes, even in the principal production areas, during the spring months. Many growers, however, do not yet have proper storage facilities, the capital or the inclination to hold their potatoes for advanced prices, and when the home markets are already abundantly supplied or when the price is low in local centers which are oversupplied, the growers must turn to the larger cities. It must be remembered that over one-half the total population of the United States is within a radius of 500 miles of New York City. Consequently this area has a consuming power equal to all the remainder of the United States combined.

The location of a suitable market is of first im-

portance. Sometimes growers may contract to produce potatoes for a canning factory at a fixed price, or the latter may guarantee to handle the growers' output at prevailing prices at digging time. The grower who is near a city may often build up a fancy trade among certain families, restaurants, hotels, or fancy stores. Such a trade is often very profitable and satisfactory. When good home markets are not available, the grower may sometimes become acquainted with some individual in other regions who is able to handle his crop. Many times a grower, because of the superiority of his product, the neat appearance of his packages, or his care in grading, will attract the attention of some reliable broker, wholesale grocer or commission-man in some city, and gain his confidence to the extent that each year he will look to this particular producer for his best stock. The grower will often find it well worth while to make an occasional trip to market and become personally acquainted with the men who buy his products. When the shipper does not personally know some buyer on the market, names of reliable dealers may be secured from the marketing department of his state agricultural college. The day of the unscrupulous dealer in town is almost over. Any standard firm or brokerage that advertises regularly in the leading trade journals may be dealt with without fear of fraud. The grower will, of course, have to use his own judgment in the way he sells in any one instance.

Home markets.

Home markets offer a better medium through which to sell than foreign ones. When potatoes are shipped to some distant city, a commission has to be paid to

some one for handling them. Any possible commission is eliminated, however, when the grower sells directly to the consumer on a home market. In addition to this, many growers prefer the home markets because they are given an opportunity to put into their sales their own individuality. They meet and know their buyer personally, become acquainted with their desires, and are better able to meet trade requirements. Such personal contact is also conducive to improvement and development in selling. The grower thereby learns the value of what would perhaps otherwise seem unimportant details of efficient salesmanship. It enables him to grow with the increasing demands of his business.

Frequently when it is not convenient or desirable to sell direct to the consumer, it may be possible to sell to small grocery stores, canning factories, storage plants, or local buyers who assume the risk of shipping. Although the gross price received from such sales is always less than from a private retail trade, it is sometimes more than the net returns would be when the additional time and expense involved in the more direct small sales are figured. Because of better organized and more efficient means of selling, a grocer can sometimes pay the grower a better net price than the latter could secure by personally peddling his potatoes. This is not always, or even frequently, the case, however, as dealers who buy usually allow enough margin to insure a good profit on such perishable goods. This is especially true of local buyers who purchase with an idea of shipping. Such men are usually well posted on market conditions and certainly keep on the safe side of purchasing prices. Commercial storage companies and local canning factories furnish one of the most sat-

isfactory means of marketing locally. Such institutions when owned and operated by progressive men can often be the means of remarkably developing the sweet potato industry in a very short time. When sold to such concerns, the grower can usually sell in as large quantities as he desires, he assumes no risk, and does not have to wait for his money.

However, when all of these advantages have been thought over, there is a dangerous tendency to yield to the most convenient method at the expense of profit. The grower should keep well posted on prevailing market conditions all over the country and after carefully calculating the relative cost, trouble and risk of selling on various markets, dispose of his goods through that channel which will probably give the greatest net return. A farmer will sometimes continue selling on one market regardless of price because of habit and his more intimate knowledge of the specific conditions there.

Foreign markets.

When sweet potatoes are marketed beyond the territorial range possible of personal attention by the grower, some third party must be entrusted with the responsibility of their satisfactory disposal. The transportation lines are responsible to a certain extent for safe delivery at destination. This, however, covers only such incidents as can be charged directly to the negligence of the transportation company, and does not relieve the shipper of errors in selection of car type and proper packing. When foreign markets are patronized, the potatoes are usually handled through a commission agency of some kind which takes its pro-rata toll for the service rendered. This commission medium may

be the regular vegetable broker in the city or a coöperative shipping association, owned by the growers themselves. Such organizations have overhead expense that must be met by requiring a certain percentage of the gross sales. When owned by growers, any tendency towards economy of sale will be in their favor, which is not true of privately operated selling mediums which must not only meet actual expenses but must make at least a living wage in profit besides.

Occasionally it is possible for a producer to cater to a private trade when his reputation for honesty, quality and fair dealing has been sufficiently established, even on the more distant markets. In developing a trade of this kind, agreements have to be made, often months in advance of delivery, with the manager of hotels, restaurants, resorts, clubs, or private houses, to use a certain quantity of a specified grade delivered at such time as may be agreed on between buyer and seller. Regions in which sweet potatoes of the best quality are not well known offer the best territories in which to work up such private trades. Thousands of individual growers all over the South have established such private trades in distant cities by sending an acquaintance in the territory samples of his most select roots, requesting the receiver to give them to his friends. Sometimes the grower will have printed on a neat wrapper his name and address and a few words concerning his potatoes. Each potato may be wrapped separately in these papers. It is nearly always necessary to send samples of the potatoes to be sold in working up private trades.

With the advance of the new scientifically constructed storage-house, the possibility of putting sweet potatoes in storage in the cities is destined to open up one of the

most important systems of marketing. If a company of progressive growers could be organized that would build a chain of commercial curing-plants in the large markets, with managers to receive the stock, store it and later sell to the jobbers and retail trade when the price was sufficiently high, a most efficient commercial storage and marketing system could be developed. In fact, if such a corporation had sufficient capital and support of the growers over the country, there is no reason why in time it could not almost control the entire sweet potato industry of this country. Without doubt the very near future will witness the growth of just such a corporation, controlled and managed as are the big corporations which now import tropical fruits.

Some factors in foreign marketing coincide with those of local marketing, and there are also many differences. It is instructing to compare these two methods of selling. The commissions, freight, and additional expense of packing make it necessary to receive a much larger price than can be obtained at home. Net prices on home markets, other things being equal, are more often greater than the net returns from foreign shipments. Competition is also greater on the big markets because the goods must measure up to the highest standards of all other sections of the country. The best of everything is shipped. The sweets must not only be the best of their variety, but the variety itself must be of the kind in popular favor. Most of the larger markets give preference to certain standard varieties, which, although perhaps not so good as some other kinds, are most popular because of prestige gained through years of continued appearance. To change such varietal market demands is a problem of judicious advertising

requiring years of faithful and patient cultivation. The growers of the South are now making united efforts to gain for their more juicy "yam" varieties prestige in the northern and western markets over the dry-fleshed Nansemond kinds, which at the present rank first in commercial demand. In shipping to foreign markets, considerable skill is necessary in making arrangements for the loading and handling of cars, and if sold personally by the shipper on the city markets, the necessary trackage and warehouse space must be provided when large shipments are involved. When extensive shipments are being made, the services of a specialist who has made a study of these conditions may be necessary. Growers are often unfair in their expectations of the home markets. They frequently ask the grocer as much for their potatoes as they would expect directly from the consumer. If there is any surplus to be shipped, it usually consists of the best and the net returns are often less than received on the home market for goods of inferior quality. Home markets everywhere are, generally speaking, capable of being developed materially above their present status.

Advertising.

Although having no effect on seasonal distribution, advertising does have, and with sweet potatoes will continue to have an ever-increasing influence on territorial distribution. There is a large field of consumption yet to be opened up in new territories where the best quality of sweet potatoes is now unknown. This will only be accomplished by advertising in one way or another. "Sunkist" oranges have been made famous by advertising, as well as scores of other articles too numerous to

mention. Advertising is sure to play a very prominent part in the future development of our sweet potato marketing system.

An attractive trade label is one of the most efficient and convenient advertising mediums at hand with the sweet potato grower. These can be printed on paper and pasted on the market container, or they may be stenciled or printed directly on the container itself. Many growers have found small printed circulars, which were placed in each package, to be highly profitable. These usually tell what variety is represented, how, where, and by whom the potatoes were grown, and they may contain some new or desirable cooking recipes. Advertising is sometimes inserted in the standard fruit and vegetable journals or papers.

SELLING AGENCIES

Sweet potatoes may be sold on local markets as already discussed; through the medium of a commission house; coöperative marketing association; or by direct personal sale to individuals or firms in distant markets.

Commission house.

Doubtless the oldest and best known method of selling sweet potatoes in the United States is through the medium of the commission-man. Long before coöperative marketing was given any serious thought by southern farmers, the commission-man was at hand to sell their produce for a specified toll out of the gross receipts. Many of the larger commission firms have sent out traveling agents who made it their business to locate centers of production and endeavor to get growers to ship to their

firm. The policy of these men has been to solicit shipments direct to the house on the basis of prevailing markets at time of arrival rather than to quote any price in advance. Commission-men have been severely criticized at times as unnecessary middle-men. In former years much of this criticism was brought on by unscrupulous dealers who did not give their customers honest service. Public opinion and sounder business principles have done much to discourage dishonest practice, however, and the commission-man has greatly simplified the farmers' marketing problem and no good way has yet been found to eliminate him from the selling program.

In selling through commission firms, the first step is to learn the names of reliable houses in the nearest markets. It would be well to write the firm several weeks before shipping season and find out how many potatoes they can use a day or a week, and their terms. It would be wise to get in touch with several firms in the respective big markets in this way. Daily Market Report sheets, which give the prevailing prices in each leading market for that day, may be obtained free of charge from the nearest office of the Bureau of Markets. These should be watched each day. Though they do not tell what a given carload of potatoes will bring a pound or a bushel, they report prices on the actual sales which took place during the day and thus give a very clear indication of the tendency of prices in the various city markets. One or two days before the grower is ready to load his car, he should wire one of the commission-men with whom he has been corresponding, who lives in the particular city where prevailing prices seem to be best as indicated by his Market Report Sheet at the

time he is ready to ship. In the telegram the grower will ask whether the commission-man can handle a certain number of cars of a particular variety, packed in a given container, loaded at a certain point on a given day. The commission-man will investigate his order for that time, calculate the time it will take the potatoes loaded at the given point to reach him and will advise the shipper whether or not he can handle them at that time. It may happen that he is already expecting the arrival of several cars from other points at that time and cannot handle the potatoes then, but would like to have them a few days later. When he advises the grower to this effect (by telegraph), the latter may be afraid to wait until that time for fear prices will fall or for some other reason. In this event he immediately tries another firm in the same manner. The Market Report sheets always indicate the demand and rate of movement in the various cities and if these reports are promptly acted on, there will never be any difficulty in finding some firm in the strongest market who can handle the shipment. It may, however, happen that some one house is over-supplied at that time.

An example of the information contained in the Market Report sheets is as follows:

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF MARKETS

Daily Market Report

Memphis, Tenn.
Feb. 15, 1919.

Rooms 601–03 Exchange Bldg.
Telephone — Main 796

No. 128

SWEET POTATOES

Reports by direct leased wire from important markets.
This morning's sales unless otherwise reported.

CHICAGO: 32° Snowing. 1 Tenn. arrived. 2 cars on track

including broken. Demand and movement good, little change in price. Sales to jobbers, Tenn. bushel hampers, Nancy Halls, quality and condition generally good, 2.50–2.65, mostly 2.65.

ST. LOUIS: 28° Snowing. 4 Tenn., 1 Ga., 1 Fla. arrived; 7 cars on track, demand and movement slow, prices slightly lower, quality and condition good, few decayed. Sales to jobbers, Tenn. bushel hampers, Nancy Halls, repacked, mostly 2.45–2.55. Georgias, bushel crates red varieties, quality and condition ordinary, slightly decayed, 1.75–2.10. Florida cloth top stave-barrels, yellow varieties, wide range in quality and condition, 5.00–5.75.

CINCINNATI: 23° Snowing. 2 Ala. 4 Va. arrived. 9 cars on tracks including broken. Supplies heavy, movement dragging, little change in price. Sales to jobbers, quality and condition generally good. North Carolinas, barrel crates, Nancy Halls, and Southern Queens, 5.75–6.25. Seed: Virginia cloth top stave barrels, Big Stem Jersey 7.00. Delawares, bushel hampers, Big Stem Jersey, 2.75, few 3.00. Alabama bushel crates 2.40–2.65.

Some growers prefer to have government inspection when the car arrives at destination, which can be secured for $2.50 a car on request. The report of the government inspector stands as conclusive evidence in any court of the United States should a suit arise concerning the condition of the potatoes on arrival. The inspector makes four copies of his report; one is kept on file; the shipper and receiver are each supplied with one; and one copy is sent to Washington to be kept on file there.

From 5 to 10 per cent of the gross sales is usually the commission charged. After being sold, the commission is deducted from the gross sales, the freight and drayage is then subtracted, and a check for the balance is sent the grower. Receipts for freight and all other money paid out by the commission-man on the producer's goods

should be sent the latter with the check for his net returns.

As has been said, the grower should never lose an opportunity to become personally acquainted with the commission-man who handles his goods. Personal acquaintance will be mutually profitable. The National League of Commission Merchants will give information concerning the reliability of any leading commission-men.

Coöperative shipping.

Intensification of state coöperative extension work from the land grant colleges has done much to stimulate coöperation in all lines of farming and especially coöperative shipping of perishable truck crops. Local agricultural agents in each county to notify the farmers of the day designated, with a state marketing specialist to place the cars, have greatly facilitated coöperative shipping of sweet potatoes throughout the southern states, where the sweet potato industry as a commercial enterprise is comparatively young, and where many of the farmers know nothing of marketing principles.

The only way in which an organized coöperative association can be formed successfully among farmers is for a specific and urgent need to exist for coöperative effort in order that some one thing of common interest may be accomplished. The need must be immediate. Frequently when some outside agency has helped a number of growers to get together to ship a car of potatoes coöperatively, the need for an organization will be recognized. Much has been said and written about coöperation within the last few years, some

of which has been practical and some more or less imaginary. Coöperation through the Eastern Shore of Virginia Produce Exchange has made New Jersey, Delaware and Virginia famous for their superior Nansemond, or Jersey Sweets. Coöperation, through the efforts of the Georgia Sweet Potato Growers Association, has made Tennessee Nancy Halls known and demanded throughout this country. The good work of similar organizations could be cited in other states. The method of forming a coöperative shipping association will depend entirely on local conditions, ability of the leaders, and the amount of sweet potatoes to be marketed. A good leader with experience and well formed plans who possesses the personality and executive ability to carry them out is an essential constituent of the association that succeeds. Coöperative shipping associations are non-profit-sharing in character, and usually meet their current operating expenses by levying a certain tax on each package or bushel of potatoes sold.

SELLING METHODS

The individual method of keeping in touch with markets and selling through commission firms, just now discussed, treats in general the methods used by any selling agency. Exchanges or large coöperative shipping associations may do sufficient business to justify them in keeping a salaried salesman in the big markets during the shipping season. This is supposed to be desirable in some instances, because regular salaried agents of the association call on the trade from time to time and solicit their business for the particular kind of brand of potatoes which the organization has for sale and is trying to establish on the market. The ad-

vantages of such work are obvious. As sweet potato shipping associations become more numerous and better organized, the commission house will be less used. The employment of a special salesman is, however, a heavy expense which the greater number of small associations cannot afford to bear, and different substitutes for such a representative have been tried. Theoretically, if a large number of separate associations had their special salesmen on the markets, they would eventually be competing against each other and thus defeat the original principles of coöperation. This condition would be likely to occur more quickly with an association handling only one commodity. Instead of employing salaried salesmen, some associations have merely agreed with some standard selling agency in the market to handle all of their output. Such an agency might, of course, make similar agreements with any number of other associations. It is possible that as the sweet potato industry grows, centralized distributing associations will eventually be established in the big cities which will handle the business of a large number of associations and exchanges all over the country. At present the exchanges either handle their sales direct or sell them to various firms already on the market.

Track and f. o. b. sales.— Perhaps the most satisfactory method of selling sweet potatoes is to contract them to a reliable firm for a specified price delivered free on board the cars. This relieves the grower of any further responsibility, does not require him to wait for his money, and when a sufficient shipment is being made to attract the buyer to the loading point, better net returns are frequently received. A track sale means selling the potatoes at the car on the track nearest the

point of production. An f. o. b. sale may specify that the potatoes are to be delivered free on board at any point that may be agreed on. The terms are, however, very closely related and are often used interchangeably.

Open consignment.— When a commission firm is well known, the usual method of selling is merely to bill the car to the firm in question on open account. Buyers frequently claim that they can handle goods to better advantage when shipped in this way. The original receivers in the big markets usually resell to jobbers. Jobbing houses have been referred to as the food banks of the country. They buy from the original receivers or commission merchants and resell to the retail stores of the country, who in turn pass the goods on to the consumers. Commission merchants prefer having sweet potatoes shipped to them on open account because it requires less immediate outlay of capital, and at the same time gives them all the privileges of complete ownership in selling to the jobbers or other buyers. If the reliability of the person to whom the grower originally consigns the goods is not known, however, it is best to have some kind of a check on his actions.

Bill of lading attached.— The shipment of sweet potatoes bill of lading attached is the method followed by a large number of small associations that have been remarkably successful in the collection of all their accounts. The car of potatoes is billed direct to a buyer. A sight draft covering the price of the contents of the car is attached to the bill of lading and goes with it. A copy of this bill is at the same time sent to the bank which handles the buyer's business. The railroad then protects the seller by requiring the buyer to go to his bank and take up the attached bill, which automati-

cally becomes a sight draft, and after being paid becomes a receipted bill. The buyer then presents his receipted bill to the railroad company, which turns over his carload of potatoes. No credit is extended, no room is left for fraud, and the seller receives his money immediately. When business is done in this way, the seller must play the game fairly and stand squarely behind his goods and his selling price. If the goods do not measure up to what they were bought for, he should make the deficiency good.

Miscellaneous methods.— Sweet potatoes are frequently sold to a considerable extent by direct sale to consumers in different parts of the country. This is a favorite way of selling seed stock. Usually advertisements are run in the classified columns of numerous farm journals and the goods are shipped by express or freight direct to the buyer. To avoid handling a large number of small accounts, the seller usually requires the order to be accompanied by the purchase price. A mode of selling sweet potatoes which has recently come into use on the markets, but with which the grower has no connection, is through the fruit auction companies. Carload lots of specified grade, variety and character are sold to highest bidders. These auction companies are usually profit-sharing corporations. Growers never consign cars directly to an auction company, they are always sent to some agent, who may turn them over to the auction company if the shipper so desires. If the car is a coöperative shipment, a manifest of the contents of the car, giving the name of each contributor and the quality, variety and grade which it contained, is made in duplicate, one copy being sent to the agent and the other to the auction company. The manifest should be sent

to arrive the day before the car, so it may be properly catalogued. Sweet potatoes sold at auction are usually inspected in the car, rather than sold from samples as with many fruits.

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